POWER PLANT ENGINEERING

Established Over 31 Years

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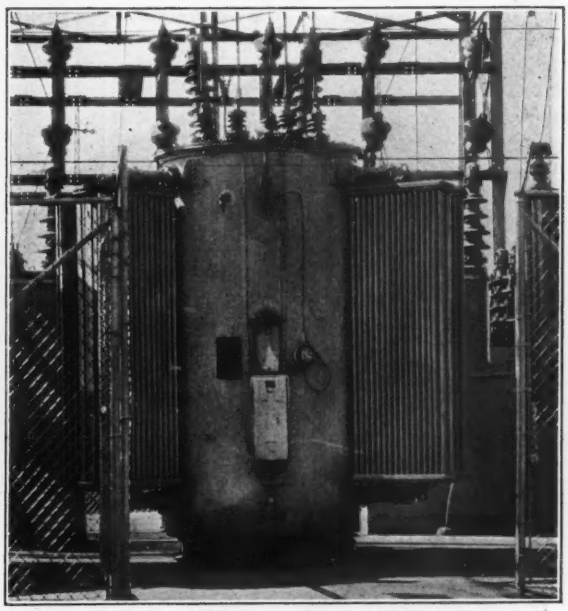


Picture of a Transformer Taking a Deep Breath

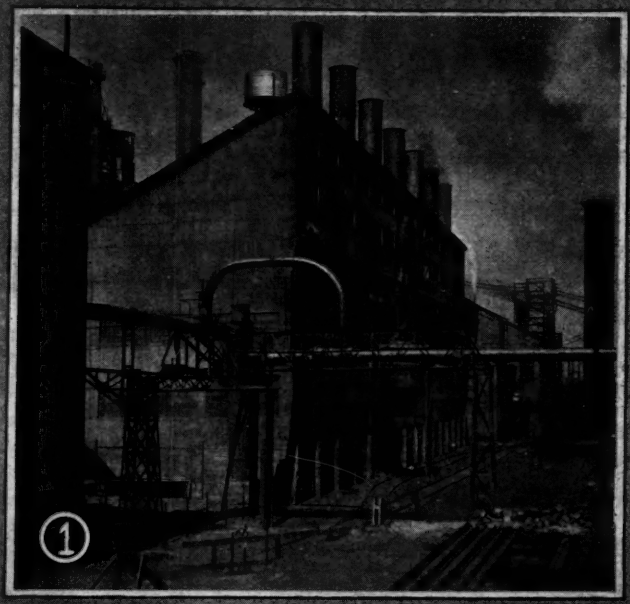
CERTAINLY, TRANSFORMERS breathe, didn't you know that? They breathe just as we do, with their lungs. Perhaps you didn't even know that transformers have lungs. Well, they have and this picture proves it. This particular transformer wears its lungs on the outside in that little cast iron watch charm hanging across its vest, where they will be handy to get at in case they need attention.

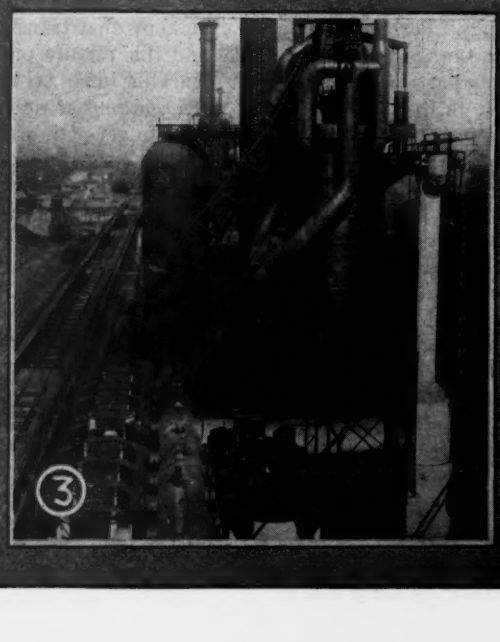
In the matter of lungs and breathing, the transformer has several advantages over us. In the first place, it breathes nitrogen instead of oxygen and since there is, roughly, four times as much nitrogen in the air as there is oxygen, the transformer gets four times as much of what it needs from a breath of air as we do. Furthermore, when its lungs are worn out (they do wear out) it is merely necessary to replace them with a new set.

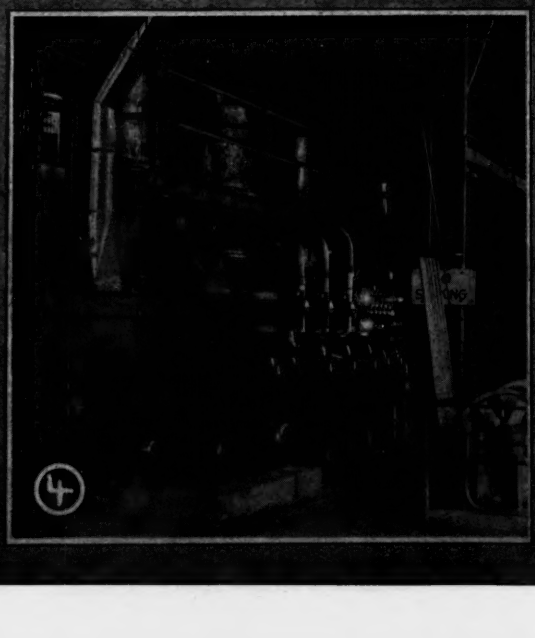
Inertaire equipment which, by the way, is what these transformer lungs are called, was developed several years ago for the purpose of protecting transformer oil from the deteriorating effect of oxidation and judging from the operating data on actual installations presented in the article by L. H. Hill on page 517 of this issue, it has proved highly effective.

New Power Plant at the Minnequa Steel Works

Fig. 1. Boiler house contains 7 boilers fired by blast furnace gas and pulverized coal. Fig. 2. Four turbo-blowers supply the blast furnaces and three turbo-generators make all power used. Fig. 3. Electrostatic precipitators clean all the blast furnace gas, 70 per cent of which is burned under the boilers. Fig. 4. A central coal preparation plant supplies pulverized coal.







Minnequa Steel Works Installs New Power Plant

GREAT PLANT OF COLORADO FUEL & IRON CO. AT PUEBLO, COLO., USES AS FUEL BLAST FURNACE GAS CLEANED BY ELECTROSTATIC PRECIPITATORS, WITH PULVERIZED COAL AS AUXILIARY FUEL, AND OPERATES TURBO-GENERATORS AND TURBO-BLOWERS. BY H. W. NEBLETT*

IN RECENT YEARS, executives and engineers in steel plants have come to realize that while power and steam cost represent comparatively only a small percentage in the total cost of producing finished steel, the total annual cost of these items is an enormous sum and the possibility of large returns from investments in modern power plant and electric mill drive equipment is assured. The average steel plant engaged in the production of pig iron, the manufacture of steel and the rolling of the various steel products, is favorably situated for utilizing the benefits of the modern steam-driven electric generating plant.

Fuel for the boilers is available in the form of blast furnace gas and, in most cases, other fuel such as coke braize, and slack or screenings from coal. The rolling of steel products in the various mills requires large quantities of electric power and the number of mills is usually great enough and the loads so diversified that a large and fairly constant electric load is available. Blowers are required for supplying air to the blast furnaces. Where these blowers are steam-turbine-driven, they can be installed in the power house with the turbo-generators, thus insuring a more diversified and steady steam demand.

Many steel plants are abandoning the various steam engine drives with their isolated boiler plants, low steam pressure, high labor and maintenance cost and poor efficiency and are installing electric motor drives for the mills, supplied with power from a centralized power plant.

The Colorado Fuel & Iron Co. has followed this trend by recently installing a power plant and electric drives for its mills in the Minnequa Steel Works at Pueblo, Colorado. This power plant has made possible great savings in the production of steel by the elimination of many steam engine drives and isolated boiler plants. A total of 75 boilers in five boiler plants have been eliminated to date and, when the electrification program for which the new power plant is designed has been fully extended, a total of 118 boilers will be abandoned.

Minnequa Steel Works is equipped for the complete process of steel making from iron ore to the finished steel. It manufactures a large range of steel products, from railroad rails to a variety of wire products, which require a large amount of power for the rolling and finishing operations. Its new power plant is a complete unit consisting of a power house, boiler house, powdered coal preparation plant and gas cleaning plant. It is operated as a separate department with a complete organization including testing, combustion and efficiency engineers, and a complete equipment of laboratory, testing and operating instruments. In its relations with the other departments of the steel plant it is operated as a utility, purchasing its fuel in the form of blast furnace gas or coal and selling electric power, steam, blast air and water. The power plant is located adjacent to the blast furnaces, as shown in Fig. 5, enabling the gas to be easily delivered to the boiler house.

*Chief Engineer for Wilfred Sykes, Consulting Engineer.

POWER HOUSE CONTAINS TURBO-GENERATORS AND TURBO-BLOWERS

Two main turbo-generator units are installed in the power house and a third unit is in the course of erection. These units are rated at 10,000 kw., 12,500 kv.a., 6600 v., 3 phase, 60 cycle. The generators are cooled by air circulating in a closed system. Thermostatic controlled doors are provided which will open and admit fresh air from the power house in case the temperature of the circulated air becomes excessive due to a failure of the cooling system.

Generators are connected to a main 6600-v. bus to which is connected the main power feeders to the mills and a tie line to the Southern Colorado Power Co. for the exchange of power. This tie line also acts as an emergency supply for auxiliary equipment in case of generator trouble. The main bus also feeds an auxiliary 6600-v. bus through a 5 per cent reactance, which permits oil switches of smaller rupturing capacity to be installed on the auxiliary 6600-v. bus. The small capacity feeders for miscellaneous power throughout the plant are connected to the auxiliary bus. It also feeds, through a transformer bank of 1500 kv.a. capacity, a 2300-v. station bus, to which is connected the motor driven auxiliaries for the power house, such as exciters, circulating water, and spray pond pumps.

Four turbo-blowers are installed for supplying air to the blast furnaces; these are connected to the cold blast lines leading to the stoves of the blast furnaces so that any blower can be connected to any one of three furnaces. These blowers are rated at 55,000 cu. ft. of air a minute at 25 lb. pressure for the altitude at which they are installed, namely, 4800 ft.

Main units take steam at 330 lb. pressure and 200 deg. F. superheat and exhaust to surface condensers.

An oil purifying system installed in the power house maintains a supply of pure oil to the bearings of the main units.

Auxiliary equipment in the power house consists of

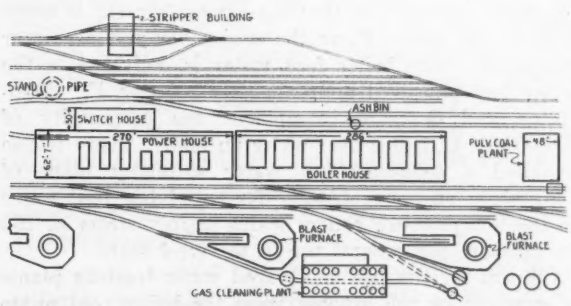


FIG. 5. BOILER HOUSE, POWER HOUSE, GAS CLEANING PLANT AND COAL PREPARATION PLANT ARE NEAR THE BLAST FURNACES

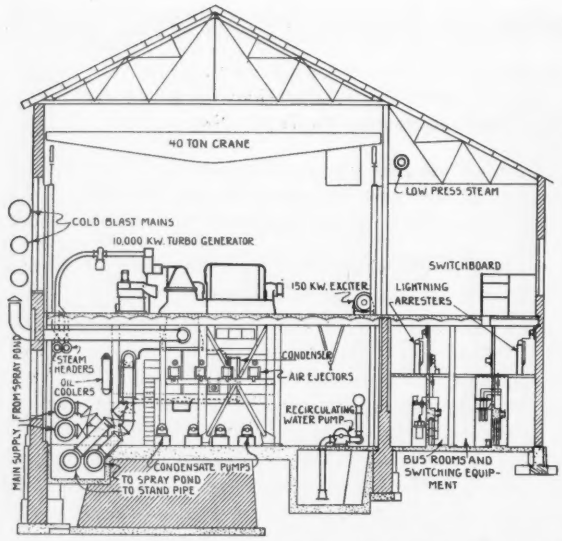


FIG. 6. SECTION THROUGH POWER HOUSE SHOWING ONE OF THE 10,000-KW. TURBO-GENERATORS AND ITS AUXILIARIES

two 150-kw., 250-v., motor-driven and one 150-kw. steam-driven exciters for supplying excitation to the main generators; two 1000-kw., 250-v., d.c. motor-generator sets feeding the d.c. power system of the steel plant adjacent to the power house; two 200-kw., dual-drive, 250-v. d.c. generators for supplying power to the various d.c. motors of the power house, boiler house, powdered coal plant, and gas cleaning plant. These dual-drive units perform two important functions: first, they insure uninterrupted power for station use; second, they furnish exhaust steam as required, in addition to exhaust steam from other sources, for the boiler feed water treating and heating equipment.

Boiler feed water for the boilers supplying high pressure steam for the power house consists of the condensate from the turbo-blowers and turbo-generators, plus the necessary make-up or raw water. Each condenser is equipped with duplicate hot-well pumps driven by d.c. motors, which are connected to separate feeders fed from the dual-drive sets. Hot well pumps deliver the condensate to a reserve feed water storage tank which takes up the fluctuations in the load. From this reserve feed water tank it is delivered to a deaerator connected with the evaporators for treating the raw make-up water. The evaporators deliver evaporated water to the deaerator where the entire boiler feed water supply is deaerated so that the oxygen content is below 0.05 c.c. per litre. From the evaporator and deaerator equipment, pure boiler feed water is delivered to the boiler feed pumps at approximately 205 deg. F. Evaporator and deaerator equipment has a capacity of 350,000 lb. of boiler feed water an hour. There is also installed a soda-lime hot water softening plant of 125,000 lb. an hour capacity for supplying feed water to the low pressure boilers which supply steam at 150 lb. pressure for general use in the steel plant.

Steam for the two boiler feed water treating plants is supplied by the exhaust from the boiler feed pump turbines, the steam-driven exciter, and the turbines on the dual-drive sets at a maximum pressure of 10 lb. There are four turbine-driven boiler feed pumps, each with a capacity of 600 g.p.m. at 860 ft. head. Two motor-driven centrifugal water pumps with a capacity of 12,000 g.p.m. each at 55 ft. head are installed for circulating condensing water to a spray pond. Three motor-driven centrifugal water pumps with a capacity of 6000 g.p.m., each at 130 ft. head, pump blast furnace drain water into the main water system for steel plant use. A motor-driven vacuum pump is installed for priming the water pumps.

Water Supply System Is Extensive

Condensing water is provided in an unusual manner. The steel plant is located in a section of the state of Colorado where the average annual rainfall is 12 in. or less. Practically all water available in this locality is from the snow banks in the Rocky Mountains, the nearest range of which is about 35 mi. west of Pueblo. Strict legislation pertaining to water rights exists in this section on account of the limited supply. The water supply system of the Colorado Fuel & Iron Co. is necessarily extensive and complicated. To insure a constant supply, the company maintains large storage reservoirs in the mountains and near the steel plant, with necessary canals and pipe lines. The total water supply for the steel plant, which is approximately 32,000,000 gal. a day, is delivered by gravity at 50 lb. pressure through pipe lines from storage reservoirs located approximately 5 mi. from the steel plant. The system is so arranged that all the water for the main steel plant is used for condensing purposes by first passing it through the condensers in the power house, which discharge into the water mains of the steel plant. Water used around the blast furnaces is collected in a sump in the power house, from which it is pumped back into the system ahead of the condensers. In case of failure or shortage of water from the main water supply, an emergency supply can be taken from an irrigation canal which runs through the plant. Water from this canal is taken through settling basins and is pumped into the water mains ahead of the condensers.

To insure sufficient cooling water at all times for the condensers, a spray pond with a capacity of 27,000

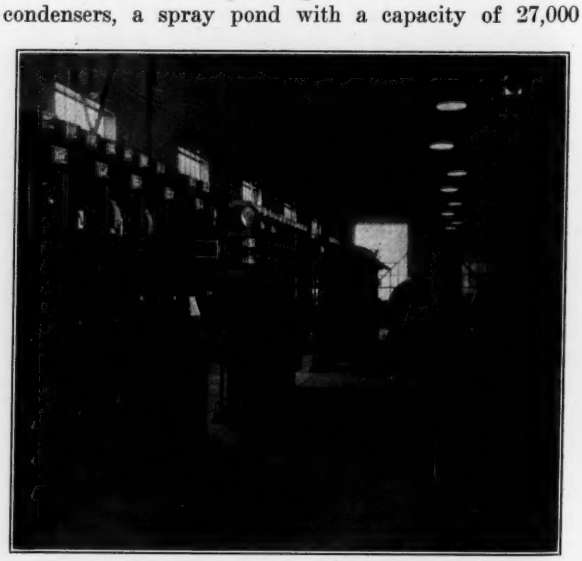


FIG. 7. FOUR MAIN AND AUXILIARY SWITCHBOARDS IN POWER HOUSE, WITH M-G SETS IN BACKGROUND

g.p.m. is provided. Water for the initial spray pond supply and for make-up to replenish evaporation can be taken either from the main water system or from an auxiliary storage reservoir located about one mile from the plant. The condensers in the power house are so arranged that any one, or all, can be connected to either the main water system or the spray pond, the elevation of which permits the cooled water to flow through the condensers by gravity. On account of the relative low humidity at Pueblo, this spray pond gives effective cooling.

Boilers Use Both Pulverized Coal and Blast Furnace Gas as Fuel

The boiler house is adjacent to and in line with the power house. Seven 1200-hp., four-drum water tube boilers, without economizers, are installed which are designed for operation at 330 lb. steam pressure and 200 deg. F. superheat. Until all the present steam consuming units are replaced with electric drive, one and sometimes two of these boilers, will be operated at 150-lb. pressure. This low pressure steam is delivered to steam lines connecting to the various low pressure steam consuming units in the steel plant, such as mill engines, hydraulic pumps and the like. When the demand for this low pressure steam has been eliminated, all boilers will be operated at 330 lb. steam pressure.

Boiler settings are of solid brick wall construction, no air cooling being provided. The inside walls of the settings are arch construction, designed so that the expansion of the bricks causes the wall to tend to move outward. This outward movement, due to the expansion, is taken care of by a steel framework of buckstays held together with heavy springs under compression. These springs allow sufficient movement of the steel binding to conform with the expanding of the boiler setting. This boiler setting is sufficiently flexible to prevent cracks through the walls; also, the arched construction of the inside or combustion face of the walls tends to hold the brick together under expansion, thus preventing cracks. The combustion chamber is liberal to permit a high rating to be carried on the boilers.

Blast furnace gas and powdered coal are used for fuel. Two boilers are equipped for burning blast furnace gas only and five boilers are equipped for burning both blast furnace gas and powdered coal. Each boiler is equipped with four horizontal gas burners of the aspirating type in which the air for combustion is mixed with the gas. These burners have a capacity of 2,000,000 cu. ft. of gas an hour for each boiler. The gas supply is delivered to the boiler room through a gas main 8 ft. 8 in. in diameter which connects through a water seal to a gas box in front of each boiler. On each box are four valves for controlling the gas to the burners.

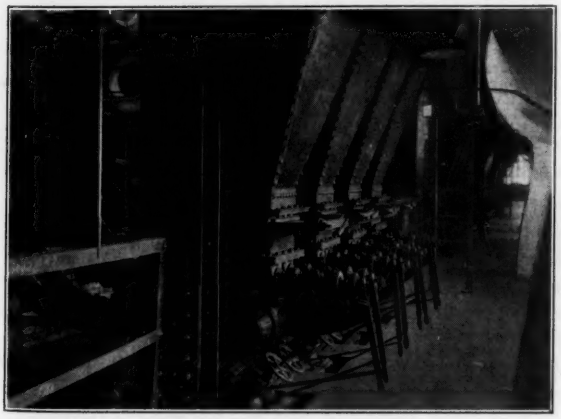


FIG. 8. EIGHT SCREW FEEDERS SUPPLY PULVERIZED COAL TO EACH OF FIVE OF THE BOILERS

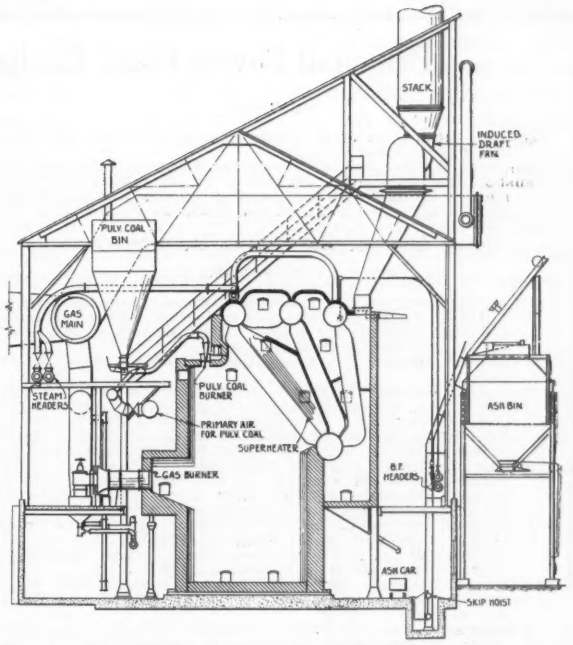


FIG. 9. FIVE OF THE SEVEN INSTALLED BOILERS USE BOTH BLAST FURNACE GAS AND PULVERIZED COAL

Blast furnace gas constitutes the main fuel. Due to the method of cleaning, this gas is delivered to the boilers at an average temperature of 375 deg. F., and in addition to the sensible heat retained, it is in an ideal condition for burning. Powdered coal is used only when there is a shortage of gas for short periods during blast furnace cast.

Powdered coal is delivered to each boiler through eight vertical burners located near the top of the combustion chamber and 17 ft. above the gas burners, Fig. 9. Screw feeders are driven by adjustable-speed, d.c. motors, controlled from the operating floor. Approximately 30 per cent of the air required for combustion is delivered under pressure through the burners with the coal. The additional air required is admitted to the combustion chamber through three rows of air doors in the front wall of the boiler setting. Each row of doors is independently operated to allow for proper adjustment of air. A maximum of 6 t. of coal an hour can be fired at each boiler; this will give a boiler rating of over 300 per cent.

A small amount of ash is deposited in the boiler settings, the majority passing out the stack with the flue gases. No hoppers or chutes are provided in the boiler settings. Ash is removed approximately once a week through cleanout doors in the bottom of the com-

Principal Power Plant Equipment at Minnequa Steel Works

General

Location—Minnequa Steel Works of Colorado Fuel and Iron Co., Pueblo, Colo.
Designer—Wilfred Sykes, Consulting Engineer, Chicago, Ill.
Construction, including fabrication of structural steel and making of castings was handled by the Machine Shops and Construction Dept. of the Colorado Fuel & Iron Co.

Prime Movers, Electrical Equipment and Auxiliaries

3 General Electric Co. turbo-generators, each 10,000 kw., 12,500-kv.a.., 80 per cent power factor, 6600-v., 3-phase, 60-cycle, 1800-r.p.m., 4-pole. Turbine takes steam at 300 lb., 200 deg. superheat.
3 General Electric Co. generator air coolers, 5250 sq. ft. each.
2 General Electric Co. motor-driven exciters, each 150 kw., 250 v., d.c., driven by 2300-v., 3-phase induction motor.
1 General Electric Co. steam-driven exciter, 150 kw., 250 v., d.c., driven by non-condensing steam turbine. Steam pressure 300 lb., 200 deg. superheat. Exhaust at 10 lb.
2 General Electric Co. dual drive generator sets for house service, each 200 kw., 250 v., d.c., driven by a 2300-v., 3-phase, 60-cycle, squirrel cage motor and a non-condensing steam turbine, exhausting at 10 lb.
5 General Electric Co. motor generator sets (2 in Power House, 3 in Mill motor rooms), 1000 kw., 250 v., d.c., for general d.c. service to steel plant. Driven by 6600-v., 3-phase, 60-cycle synchronous motors.
4 General Electric Co. switchboards, 1 main 6600 v.; 1 auxiliary 6600 v.; 1 2300-v. station board; one 250-v. d.c. board.
4 Ingersoll-Rand Co. blast furnace turbo-blowers, five-stage, water-cooled, centrifugal, capacity 55,000 c.f.m. at 25 lb., 2950 r.p.m., constant volume governor. Turbine takes steam at 330 lb., 200 deg. superheat.
3 Wheeler Condenser and Engineering Co. surface condensers for turbo-generators, each 15,000 sq. ft., two pass. Equipped with duplicate steam-jet air ejectors and duplicate two-stage hot-well pumps driven by 10-hp., 250-v., d.c. motors.
4 Wheeler Condenser and Engineering Co. surface condensers for turbo-blowers. 4000 sq. ft. tube surface. Two pass. Each condenser equipped with duplicate steam jet air ejectors and duplicate hot well pumps driven by 7.5-hp., 250-v., d.c. motors.

Feed Water Treatment Apparatus and Pumps

2 The Griscom-Russell Co. evaporators for boiler feed make-up. Operate either single or double effect. Capacity 10,000 lb. an hr.
1 The Griscom-Russell Co. deaerator and heater for high-pressure boiler feed. 350,000 lb. an hour.
1 Graver Corp. hot-process, soda ash-lime water softener for boiler feed for low-pressure boilers. Capacity 125,000 lb. an hour.
4 Ingersoll-Rand Co. boiler feed pumps, A. S. Cameron type, No. 4 H. M. T., 3-stage, 600-gal. per min., 860-ft. head, driven by Westinghouse 195-hp., type MD steam turbines, 300 lb. throttle pressure and 10 lb. back pressure. Fisher Governor Co. pump governors.
2 Ingersoll-Rand Co. centrifugal pumps for spray pond, A. S. Cameron type No. 18 F. V., 12,000-g.p.m., 55-ft. head, driven by General Electric 250-hp., 2300-v. induction motors.
3 Ingersoll-Rand Co. centrifugal pumps for recirculating water, A. S. Cameron Type No. 18 F. V., 6000-g.p.m., 130-ft. head, driven by General Electric 250-hp., 2300-v. induction motors.
2 Ingersoll-Rand Co. centrifugal pumps for delivering water from reserve feed water tank to feed water system., A. S. Cameron Type No. 3 L. V., 200-g.p.m., 70-ft. head, driven by General Electric 10-hp., 250-v., d.c. motors.
1 Nash Engineering Co. vacuum pump for priming above pumps.

Boilers, Superheaters and Accessories

7 The Casey-Hedges Co. 4-drum water-tube boilers, each 1200 hp., 330 lb. steam pressure. Three boilers to be operated at either 330 lb. or 150 lb.
14 Northern Equipment Co., Copes feed water regulators, operating in duplicate on each boiler.
7 The Superheater Co. superheater installations in first pass to deliver 200 deg. superheat to high-pressure steam, 150 deg. to low pressure steam.
8 Diamond Power Specialty Corp. soot blowers in each boiler, installed in pairs, one on either side, or a total of 16 units per boiler.
7 Green Fuel Economizer Co. induced draft fans, one on each boiler, each 110,000 c.f.m. against a total static head of 1¼ in. water, double inlet. Each fan driven through a flexible coupling by a 60-hp., 200 to 400-r.p.m. adjustable-speed, 250-v., d.c. motor, with Carrick Engineering Co. speed regulators.
7 Plate steel stacks, each 7 ft. diameter and 40 ft. high from fans, with plate steel breechings, all fabricated by Colorado Fuel & Iron Co.
7 Boiler settings, brick, solid wall construction. Held by flexible compression spring binding. Suspended arches by American Arch Co. No water screens required.
Ash handling equipment.....R. H. Beaumont Co.
4 Gas burners per boiler, horizontal aspirating type, capacity 2,000,000 cu. ft. per hr. per boiler. Designed by Wilfred Sykes, made by Colorado Fuel & Iron Co.
8 Fuller Lehigh Co. powdered coal burners per boiler, five boilers equipped. Screw feeders driven by variable-speed, d.c. motors. Capacity 6 t. powdered coal an hour.
3 B. F. Sturtevant Co. primary air blowers, 20,000 c.f.m. capacity at 6-in. static pressure. Driven by General Electric 60-hp., 1170-r.p.m. motor.
Blowoff valves, 2½-in. tandem.....Yarnall-Waring Co.
Safety valves, three 4-in. per boiler.....American Schaeffer & Budenburg Corp.
Water columns.....Reliance Gauge Column Co.
Non-return valves, 10-in.....The Edward Valve & Mfg. Co.

Piping, Valves and Insulation

All steam and boiler feed piping, 400-lb. American standard; male and female flanged joints; fittings and connections welded. .....Pittsburgh Piping and Equipment Company
Expansion bends used; Hancock monel metal, cone seat valves, 2 in. and under; Chapman gate valves; Reading globe valves; Crane l. p. steam valves; P. P. & E. Co. separators, all furnished with piping by Pittsburgh Piping & Equipment Co.
All insulation for steam and boiler feed piping, boilers, breechings, gas piping and precipitators.....Johns-Manville Corp.

Coal Pulverizing Plant

1 Fuller Lehigh Co. rotary coal drier, 5 ft. 6 in. by 42 ft.; indirect fired by pulverized coal; capacity 15 t. an hour; motor-driven.
3 Fuller Lehigh Co. 46-in rotating ball, screen type pulverizing mills; capacity 6 t. an hour each. Motor-driven.
2 Fuller Lehigh Co. 6-in. Fuller-Kinyon pumps; capacity 18 t. an hour; motor-driven.
1 R. H. Beaumont Co. automatic skip hoist; capacity 50 t. an hour. Automatic load and dump. Motor-driven.
1 Cutler-Hammer Mfg. Co. plate type magnet and 1 magnetic pulley.
2 Ingersoll-Rand Co. motor-driven air compressors for delivering air to transport line. 250 c.f.m. capacity at 80 lb.
Spiral conveyors, drag conveyors, belt conveyors.....Jeffrey Manufacturing Co.; E. C. Horne Machinery Co.
Speed reducers for drives .....W. A. Jones Foundry and Machine Co.
Motors for driving equipment, 220-v., 3-phase, 60-cycle, induction..... General Electric Co.

Gas Cleaning Plant

16 The Research Corp. Cottrell precipitator units now installed; capacity each 10,000 c.f.m. 8 precipitator units under construction; capacity 25,000 c.f.m. each.
17 The Research Corp. rectifiers and control switchboards.
Automatic rapping control equipment.....Cutler-Hammer Manufacturing Co.
17 Westinghouse Electric & Mfg. Co. transformers, single-phase, 25-kv.a., 220-v. primary, 65,000-v secondary.
Air cylinders for rapping and valve operation.....Westinghouse Electric & Mfg. Co.
Disconnect switches, bus supports, and specially designed air-cylinder-operated, high tension circuit switches.....Delta-Star Electric Co.

Miscellaneous Equipment

1 Spray Engineering Co. two-section spray pond; capacity 27,000 g.p.m.; 136 groups of five nozzles each, each nozzle 40 g.p.m. at 7 lb.
Main drive motors for mills; 6600-v., 3-phase, 60-cycle induction and 600-v. d.c. variable-speed.....General Electric Co.
Reduction gear sets installed between a.c. motor drives and mills.....Falk Corp.
Oil circulating and purifying equipment for reduction gear sets and bearings.....S. F. Bowser and Co., Inc.
Centrifugal oil purifier for power house.....DeLaval Separator Co.
Ventilating system for power house....B. F. Sturtevant Co.
Transformers, switches, protective devices, instruments, relays .....General Electric Co.
Lightning arresters, power house, General Electric Co.; mill-end trans. lines.....Westinghouse E. & M. Co.
Bus supports and insulators.....Delta-Star Electric Co.
Stairways .....Colorado Fuel & Iron Co.
Gratings .....Irving Iron Works
Steam traps .....The C. E. Squires Co.
Motor operators for valves, Dean control, on cold blast air lines .....Cutler-Hammer Mfg. Co.
Expansion joints between:
Blower units and condensers.....Crane Co.
Generator units and condensers...C. H. Wheeler Mfg. Co.
Steam flow meters and pyrometers, integrating, indicating, recording .....Republic Flow Meters Co.
Draft gages .....Bailey Meter Co.
Recording thermometers .....The Bristol Co.
Indicating thermometers.....Taylor Instrument Cos.
Recording and integrating Venturi meters.....Simplex Valve & Meter Co.
1 Turbine room crane, 40 t. with 5-t. auxiliary hoist.....Shaw Electric (Manning, Maxwell & Moore, Inc.)

bustion chamber, loaded into a small car which discharges into a skip hoist and delivered to a storage bin outside the boiler house. No water screens are required, as the combustion chambers are designed so that the bottom is sufficiently cool to prevent slagging.

Short individual stacks are installed for each boiler. Draft is maintained by an induced draft fan at each boiler, driven by an adjustable-speed d.c. motor. The speed of the fan is controlled by a regulator which maintains approximately 0.2 in. of draft in the combustion chamber at all times, irrespective of the quantity of gas or coal fired. This maintains a uniform combustion condition for all loads on the boiler. The exit temperature of the flue gas from the boilers averages 600 deg. F.

Feed water at approximately 200 deg. F. is delivered to the boilers and water level is maintained in the boilers by duplicate feed water regulators. Blowing down of the high pressure boilers is not necessary, as pure

FIG. 10. GENERAL VIEW OF POWER HOUSE BASEMENT

water is delivered by the evaporating and deaerating equipment. These boilers are kept in service continuously except for periodic inspection. Superheaters are installed between boiler tubes which give uniform superheat under varying load. Steam at 330 lb. pressure and 200 deg. F. superheat is delivered to duplicate 12-in. steam headers which connect to the main units in the power house. All steam piping is made up with male and female joints and all fittings and connections are welded.

Present average load on the high pressure boilers is 300,000 lb. of steam an hour with peaks of 340,000 lb. an hour, or an average of 60,000 lb. an hour per boiler. The low pressure steam load averages 50,000 lb. an hour per boiler.

Powdered Coal Preparation Plant

As shown in Fig. 5, a central coal pulverizing plant with a capacity of 18 tons per hour is installed in a separate building approximately 100 ft. from the boiler house. A central system was decided on rather than a unit system for each boiler on account of smaller total pulverizing capacity required, the elimination of raw coal conveying and storage equipment in the boiler house and greater flexibility. Since powdered coal is used mainly as an auxiliary fuel, comparatively little coal is required over a period of a day or week but the demand may be heavy for short periods of from a few minutes to a half hour, due to a shortage in gas supply when furnaces are casting or are down for changing tuyeres and the like. The coal in this territory contains little moisture and most of the time can be pulverized and stored without drying. A drier is included in this installation, however, for use at times when the surface moisture of the coal is high on account of transporting through rain or snow. Pulverized coal can be stored in the bins above the boilers for several days, as the temperature around the bins is sufficient to prevent caking.

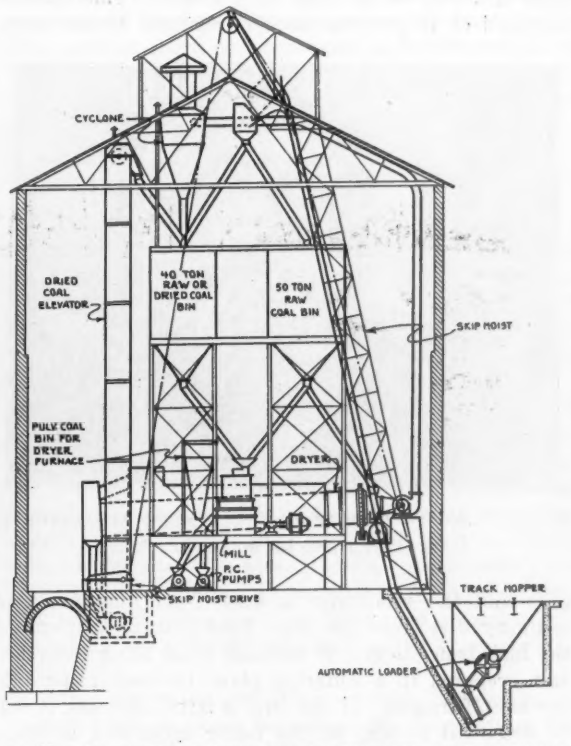


FIG. 11. COAL PREPARATION PLANT CONTAINS THREE MILLS, ROTARY DRIER AND AUXILIARIES

Coal pulverizing equipment consists of three screen type pulverizing mills, Fig. 4, with a capacity of 6 t. an hour each; one indirect-fired rotary coal drier; two 6-in. Fuller-Kinyon pumps; one 50-t. raw coal bin; one 40-t. dried coal bin; one automatic skip hoist with a capacity of 50 t. an hour handling raw coal from track hopper to receiving hopper; and the necessary auxiliary transporting and conveying equipment.

Slack coal from the company's mines, or screenings from the coal delivered to the coke plant is received in dump bottom railroad cars, weighed and unloaded into a track hopper alongside the powdered coal plant. The coal is then taken by a skip hoist to the top of the building and dumped into a hopper from which it passes over a magnet before drying and pulverizing. Fuller-Kinyon pumps send the pulverized coal, after it has been sufficiently aerated to flow freely, through a 5-in. transport pipe to the storage bins located above the boilers. A remote control and signal system is installed in connection with the transport and storage system. All equipment is driven by electric motors, the

control of which are assembled, with the transport signal system, in such manner that the operator can control any part of the operation from one central point, Fig. 4.

Gas Cleaning Plant

Each blast furnace of the Colorado Fuel and Iron Co. produces an average of 55,000 cu. ft. of gas per minute, measured under standard conditions of 60 deg. F. and 30 in. barometer. This gas contains approximately 98 B.t.u. per cu. ft. It leaves the blast furnace at about 400 deg. F. temperature and contains an average of 4 grains of dust per cubic foot of gas, and at times this will be as much as 6 grains. This dust is composed of 42 per cent iron, 11 per cent carbon from

FIG. 12. BOILER FEED WATER TREATMENT APPARATUS IS IN SOUTH END OF BOILER HOUSE

coke and the remainder is dust from limestone and ordinary dirt from the ore. This dust, on account of the high iron content, is valuable after being recovered and prepared in a sintering plant for recharging into the blast furnaces. If the dust is left in the gas, it will be deposited as slag on the boiler tubes and settings, also on the brick checkers in the blast furnace stoves. Approximately 30 per cent of the total gas from the blast furnace is used, after cleaning, for heating the stoves. The remainder is used at the boilers for making steam.

The usual method of cleaning blast furnace gas is the wet washing method, employing water. This method, while effective in cleaning the gas, has several disadvantages in this case. The sensible heat in the gas is lost as the gas is saturated with moisture and reduced to approximately 80 deg. F. The gas also carries water in the form of mist which entrains some of the dust. This dust is deposited in the gas mains or is liberated at the burners. To eliminate these disadvantages, it is necessary to heat the gas after wet washing, which involves additional equipment. The washing of the gas requires large quantities of water with the attendant pumping charges. The water as discharged from the gas washer contains the dust in the form of sludge. In order to recover this sludge it is necessary to pass the water through a settling basin or Dorr thickener. The above disadvantages are common to all wet washing installations.

At this plant additional restrictions exist in that sufficient water for wet washing is not available and that the waste water from such a plant could not be returned to the river. These conditions made it necessary, therefore, to use some other system.

Accordingly, the Cottrell electric precipitation process has been installed. This process consists of passing the gas through tubes or between partitions, in the center of which are suspended small wires insulated from the tubes or partitions. A high voltage uni-directional current is applied to the wires and the particles of dust in the gas pick up a charge when passing through this zone and are deposited on the walls of the tubes or partitions. At regular intervals of approximately once an hour, the current and gas are cut off from each unit and the tubes or partitions rapped, which causes the dust to drop into the lower part of the cleaner. The dust is then discharged into a bin from which it is dumped into railroad cars and taken to the sintering plant.

The original installation at Pueblo consists of 16 units. Each unit has a capacity of 10,000 cu. ft. of gas a minute, or a total capacity for the installation of 160,000 cu. ft. of gas a minute at the temperature delivered to the units, which averages 380 deg. F. The present units clean the gas from two blast furnaces.

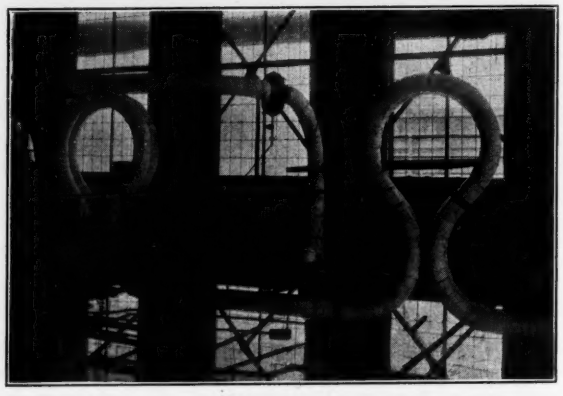


FIG. 13. EXPANSION BENDS IN MAIN STEAM HEADERS IN POWER HOUSE

Additional units are now being installed which will give a total capacity for this plant of 360,000 cu. ft. of gas per minute. The original precipitator units are known as the tube type. The units now under construction are the plate type and consist of a series of plates or partitions between which the electrode wires are installed.

Electrical equipment for the precipitators is located in a house adjacent to the unit. There is also installed an automatic electric timing and rapping control. This control automatically cuts off the gas and electrical supply to each unit, raps the dust from the tubes, closes the electric circuit, and opens the gas supply valve. Units are rapped one at a time in sequence. The interval of time between rapping periods can be varied over a range of 20 min. to one hour. A push button is provided on each unit panel, which enables the operator to rap any unit at will, in addition to the regular rapping period.

Cleaned gas contains an average of 0.2 grains of dust per cubic foot and this figure can be reduced to

any amount desired by reducing the flow of gas through the precipitators. Gas is cleaned without reducing the temperature. The absence of moisture provides a better gas for combustion and eliminates the necessity of flushing or washing out the gas mains or burners. The dust is received in a dry form, is easily handled, flows by gravity from precipitators to railroad cars, and is in ideal condition for sintering and returning to the furnaces, thus converting a by-product, ordinarily perplexing to handle, into an iron bearing material of real value in the furnace charge.

The total power required for operating the gas cleaning plant is 80 kw. The equipment being automatic in operation requires a minimum of labor and supervision. The maintenance is negligible, the operating cost is low, and the annual return on the investment is approximately 30 per cent, based on the increased efficiency of the cleaned gas and the value of the dust recovered. This is after all operating and maintenance costs have been deducted.

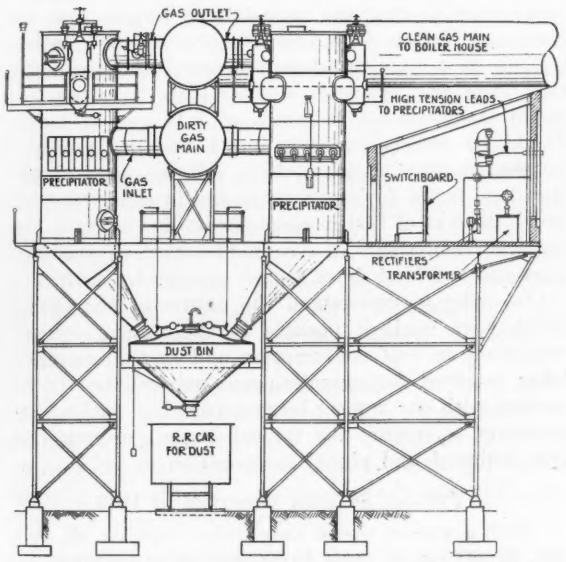


FIG. 14. SECTION THROUGH GAS CLEANING PLANT

This gas cleaning plant has been in operation one year and has proved entirely satisfactory. It is the only commercial installation of electric precipitators in America for cleaning the total gas delivered by blast furnaces.

Distribution and Consumption of Power

Current is distributed from the power house at 6600 v., 3 phase, 60 cycles, also as 250-v. direct current, on an overhead distribution system supported on structural steel towers. Lightning arresters are installed at both the power house and distributing or mill end of the circuits. The 6600-v. alternating current is distributed on individual lines to each mill or department. The 250-v. direct current is distributed into a general direct current distribution system for the plant. The motor generator sets in the power house supply direct current to that part of the system in the vicinity of the power house. They also connect by means of tie lines to other centers of direct current distribution, such as the rod mill, in which two 1000-kw., 250-v. d.c. motor-generator sets are installed. The motor rooms of the different mills act as substations in which the 6600-v. lines from the power house terminate in a bus structure to which is connected the motors, motor generator sets, rotary converters and transformers. Here are also located the a.c. and d.c. switchboards for controlling the motors and for the distribution of power. The normal week day electric load on the power house varies from 16,000 to 19,000 kw., depending on the demand from the mills.

Design of the power plant and the steel plant electrification were carried out by Wilfred Sykes, consulting engineer of Chicago, who also supervised construction. The machine shops and construction department of the Colorado Fuel and Iron Co. handled all construction work, including the fabrication of the structural steel and the making of all castings.

Smokeless Coal

"SMOKELESS COAL," according to a statement by O. P. Hood, of the U. S. Bureau of Mines, at the International Conference on Bituminous Coal, has various meanings. To the layman, it simply means a fuel which burns without smoke under the simple combustion conditions available to him; to the dealer in coal, it is merely a trade name applied to those of our semi-bituminous coals which smoke but little due to their relatively low volatile content; to the combustion engineer, the phrase raises a query. Is it the coal that should be called smokeless, or is it the combustion conditions supplied by furnace, grate and draft that should be called smokeless? To him all coals are smokeless, provided he be not limited in his method of burning them. Our highest volatile coal can be burned smokelessly if conditions are properly adjusted to the characteristics of the fuel.

After discussing the effect of high percentages of volatile gases on smoke formation, Mr. Hood states that the smoke problem can hardly be laid entirely to the small percentage of bituminous coal burned in some sections of the country, intimating that provision for burning and method of firing are vital factors in smokeless combustion.

Quoting from Bureau of Mine's Bulletin No. 230 on "Analyses of Samples of Delivered Coal" by Snyder, a number of typical analyses are discussed and reference is made to a large number of available coals having excellent steaming qualities such as low ash, sulphur and other impurity content.

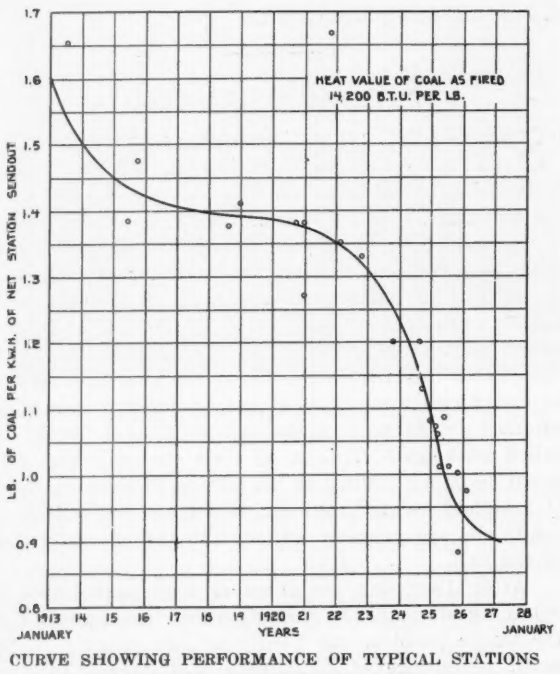
This term "smokeless coal" is a challenge to the combustion engineer. None of his art is needed to make anthracite and coke burn smokelessly, but as increasing amounts of volatile matter are associated in the fuel, more and more demands are made upon his skill in furnace design, in adaptation to service and to care in operation to keep within absolute or even practical smokeless limits. Illustrations can be found of smokeless performance of every fuel, so that the statement can be made "that it can be done." That it is not done simply indicates that it is not wanted badly enough to pay the price. Most engineering is a compromise among conflicting requirements.

Present Tendencies of Steam Station Design*

REVIEW OF PROGRESS THAT HAS BEEN MADE SINCE 1913, DISCUSSION OF LATEST DEVELOPMENTS AND OUTLOOK FOR THE FUTURE. BY VERN E. ALDEN†

TO OBTAIN an understanding of the present day tendencies in steam station design, it is necessary to review the progress made in recent years.

The underlying motive which has spurred power station engineers on has been the desire to build steam generating stations which would obtain: (1) a high degree of reliability in operation; (2) low fuel cost per kw-hr. of net station output; (3) low cost of operating labor; (4) low maintenance cost; (5) low investment and corresponding low fixed charges per kw-hr. of station output; (6) a station designed and built, so well



CURVE SHOWING PERFORMANCE OF TYPICAL STATIONS PLOTTED AGAINST DATE OF INITIAL OPERATION

fitted for the work which it shall be called upon to perform, not only during the first year of its operating life but also during the later years of its life, that it shall be unnecessary to undertake any major program of rebuilding in the future.

The extensive programs of steam station construction made necessary by the growth of loads of the electric light and power companies have given the power station engineers ample opportunities to develop improved designs and to test these designs quickly by actual operation.

IMPROVEMENTS HAVE COME RAPIDLY

Rapidity with which improvements have been developed has been rather startling, as indicated by the accompanying curve which represents the weighted average of the coal consumption in pounds per kilowatt-hour of net station send-out for a number of typical stations of 60,000 kw. capacity and higher plotted as ordinates with the dates of initial operation for the different stations as the abscissa. The operating results for the different stations have been reduced to a common basis as regards quality of fuel, coal having been assumed as having 14,200 B.t.u. per lb. as fired. It is to be noted that in 14 yr. time the coal consumption for typical stations has been reduced from 1.6 lb. of coal per kw-hr. to 0.9 lb. per kw-hr.

This improvement in operating performance appears even more remarkable when it is remembered that there is in this country quite a number of steam generating stations of 50,000 kw. capacity and higher, in connection with which the coal consumption is from 2 lb. to 2.4 lb. per kw-hr. of net station send-out.

While the stations taken as a basis for plotting the curve are referred to as typical stations, it should be borne in mind that the two stations having coal consumptions below 1 lb. per kw-hr. are not entirely typical, as a number of well-designed stations, which have gone into operation during 1926, have coal consumptions somewhat in excess of 1 lb. per kw-hr. It should be clearly borne in mind that it is only in connection with stations which will be operated at a high load factor for many years and in connection with which the cost of fuel in cents per million B.t.u. is high, that the refinements in design necessary to produce a kilowatt-hour for 1 lb. of coal or less can be justified.

In order to understand the nature of the changes which have made it possible to effect these sweeping reductions in coal consumption and in the amount of labor required for operation and maintenance in connection with our typical large generating stations, it is necessary to picture the typical steam generating station designed and placed in operation in 1913.

TYPICAL STATION DESIGNED IN 1913

Such a station would have had a capacity of, let us say, 45,000 kw. in three 15,000-kw. steam turbines, each with a 27,000-sq. ft. two-pass surface condenser, and air pumps of the hurling water type. In the boiler house there would have been installed 18 straight tube, longitudinal drum boilers, each having an area of 10,000 sq. ft., with convection type superheaters. Steam would have been delivered at 190 lb. per sq. in. gage pressure and a total temperature of 500 deg. F. Each boiler would have been fired by a 10-retort, 17-tuyere underfeed stoker with hand operated dump grates. Forced draft fans for the stokers and natural draft chimneys would have been employed. For continuous operation for extended periods of time the output of the boilers would have been limited to 200 per cent of their normal rating. If operated at this maximum rating for any appreciable percentage of the operating hours, extended outages for the repair of the brick settings would have been required. Forced draft fans and most of the other auxiliaries would have been driven by means of steam turbines. For the circulating pumps and the separate exciter, dual drive by motor and turbine would have been provided for reliability and to control roughly the amount of the exhaust steam required for feed water

*Abstract of paper presented at A. S. M. E. Convention, Kansas City, Mo., April 5, 1927.

†Engineer in Mechanical Division, Stone & Webster, Inc.

heating. Auxiliary exhaust would have been used in open feed water heaters. Air for cooling the generators would have been passed through an air washer and perhaps discharged through an air duct into the basement of the boiler house. Each boiler would have been operated as a separate unit and only a scanty complement of instruments would have been provided in the boiler room for the guidance of the firemen.

Rise in Steam Pressure and Temperature

One method of improving station economy was seen to be in raising the initial steam pressure. This has been done gradually until in 1925, Philo, Twin Branch and Crawford Avenue stations were put in operation at pressures of 550 lb. and in 1926 a 3000-kw. turbine operating at 1200 lb. was installed at Edgar Station and a 10,000-kw. unit to operate at 1400 lb. is now being installed there.

Advantages of raising steam temperatures were also recognized very early. This also was done gradually, accompanying the rise of steam pressures; the concomitant development of interdeck and radiant heat superheaters to meet the new conditions has finally made it possible to design the latest turbines and boilers, such as those at Crawford, Twin Branch and the latest 94,000-kw. unit at Long Beach, for total temperatures of 750 deg.

Reheating of steam to its original temperature after it has expanded only part way through the turbine has led to still further economies. At present there is either in operation or under construction, about 600,000 kw. of turbine capacity designed for 550 lb. steam pressure and about 725 deg. total temperature at the throttle, all designed for a single stage of reheating to the initial 725 deg.

Troubles with cast-iron economizers to meet these conditions of pressure have led to the development of the steel tube economizer, the feed water having all its dissolved oxygen removed to prevent pitting troubles originally encountered. Induced draft fans with the economizer have come into extensive use.

Bleeding the Turbine to Heat Feed Water

Use of steam bled from the turbine for feed water heating has also opened up many possibilities and practically all the stations put in operation since 1923 have been designed for the regenerative cycle of operation. A major advantage of this cycle is that it permits increasing the output from a given size of turbine. The factor which fixes the overall proportions of turbines is the volume of steam which passes through the last blades, but the output is increased by the power generated by the steam which is expanded only part way through the turbine. Another outstanding advantage of the regenerative cycle is the overload capacity it makes available on the turbine at a time of year when the peak demand usually coincides with low condensing water temperature. By shutting off the two top stage feed water heaters, the output of a turbine designed for four-stage bleeding may be increased, with only a small increase in coal consumption due to the lowering of the feed water temperature.

In using the regenerative cycle to heat feed water to a temperature of from 300 to 375 deg., it is not possible in most cases to have the feed water pick up much heat in passing through an economizer or to reduce flue gas temperatures materially. If the coal consumption is to be further reduced, however, the heat loss in the flue gas should be reduced by some sort of a heat trap between boiler and stack. This has taken the form of the air preheater, which has been rapidly developed so that it can now heat air from room temperature to about 500 deg., with a corresponding reduction in flue gas temperature from about 725 deg. to about 350 deg.

With the increasing use of the induced draft fan and the ability to remove gas from the furnace as fast as it could be burned, higher boiler ratings and higher rates of combustion with stokers have been attained. This has brought about a notable increase in furnace volumes to lessen clinker and slag troubles and insure good combustion. This has given rise to problems of furnace design of great magnitude to provide for expansion and mechanical difficulties.

Limitations in output from boilers and furnaces are at present imposed by clinker formation, slag on lower rows of tubes and brickwork maintenance. We must proceed carefully in going to the use of new types of boilers embodying new problems of circulation. Use of preheated air and desire to limit excess air has brought about further increases in furnace temperatures and further brickwork troubles.

To correct these, hollow walls ventilated by combustion air have been used, but the complication of their design and the doubts as to their use with air at 500 deg. have led to the designs in which firebrick walls are eliminated as far as possible and water tubes connected into the boiler circulation and in some cases protected by cast iron blocks form wholly or partly the walls of the furnace. Such water cooled walls, though expensive, allow higher combustion rates because of reduction of brickwork troubles, permit reduction of excess air and reduce furnace maintenance.

Pulverizers and Stokers

Use of pulverized coal has also come about rapidly in the last 5 yr. At the Lake Shore Station it was shown that an overall gross boiler room efficiency of 90.4 per cent could be obtained for a month's time with a combined installation of boilers and economizers. At Cahokia, a gross boiler room efficiency of 81.2 per cent over a month's time has been obtained without economizers and with an inferior coal. Pulverized fuel has been a real contribution to design and operation, of itself and also in pointing the way to major improvements in furnace design in connection with stokers.

Many installations of unit pulverizers have been made in the last two years.

In parallel with the developments in pulverized coal burning have been major improvements in stoker design. We now have underfeed stokers 30 ft. wide and 20 ft. long. Underfeed stokers are available for operation with air temperatures of 400 deg. and for the burning of as much as 35,000 lb. of coal an hour in a single furnace. Chain grate stokers of extremely large size have been developed with improvements in both front and rear arch reducing loss of combustible.

Extensive use of the regenerative cycle has tended to displace turbine driven auxiliaries by motor-driven ones, resulting in a reduction of the "unaccounted for" losses. In many cases it is possible to improve materially the performance of equipment, such as con-

densers, air preheaters and the like by backing it up with a greater amount of low-priced auxiliary power to improve water and gas flows and increase heat transfer.

Other trends are the use of evaporators, closed ventilating systems for generators, improved surface condensers, automatic control equipment, and so on.

Increase in size of boiler and turbine units has been rapid, being forced upon engineers by the rapid growth of load and by the interconnections that have increased the size of our systems. Supplementing these underlying reasons was the desire to reduce fixed charges and labor costs. We are planning to use in the near future turbines of 160,000, 165,000 and 200,000 kw. capacity. Boilers have been installed recently with 41,500 sq. ft. of heating surface each.

Increase in size of equipment and installation of centralized or semi-automatic control equipment have been responsible for sweeping reductions in the amount of physical labor required. Increase in the unit costs of the remaining labor have tended to counterbalance this.

Relative Effect of the Various Factors

It is interesting to form a judgment as to the relative effects which the different factors have had in effecting

TABLE SHOWING RELATIVE VALUES OF DIFFERENT FACTORS EFFECTIVE IN REDUCING COAL CONSUMPTION

Coal consumption in pounds per kilowatt-hour of net send-out for a typical station placed in operation for the year 1913	1.6 lb.
Reduction in coal consumption in pounds per kilowatt-hour resulting from—	
1. Increase in steam pressure	0.097 lb.
2. Increase in steam temperature	0.087 lb.
3. Use of higher boilers and air preheaters or economizers	0.11 lb.
4. Use of regenerative cycle for feed water heating	0.067 lb.
5. Elimination of stray losses due to the use of electric drive for power station auxiliaries	0.084 lb.
6. Improvement in the performance of surface condensers and their auxiliaries.	0.025 lb.
7. Use of automatic combustion control equipment	0.017 lb.
8. Gain due to reclaiming in the condensate the losses from the generators and turbine oil coolers	0.008 lb.
9. Improved performance of turbo-generators and (increase in overall Rankine cycle efficiency ratio)	0.05 lb.
10. Improvement in combustion efficiency due to improved fuel burning equipment and improved furnace design	0.055 lb.
Total reduction in pounds of coal burned per kilowatt-hour of net station send-out	0.6 lb.
Coal consumption in pounds per kilowatt-hour of net send-out for a typical station placed in operation for the year 1926	1.0 lb.

the reduction in coal consumption from 1.6 lb. of coal per kw-hr. to 1.0 lb. of coal per kw-hr., the value which I think we may take as typical of the best average practice in our newer stations. In the table, I have given my judgment as to the relative weights of the different factors which have been responsible for the sweeping reduction in coal consumption. It is to be borne in mind that this analysis is based on certain generalized approximations and it is of value only as it enables us to fix the relative importance of the different improvements in our minds.

One of the most interesting power station installations now in the course of construction is an addition to the South Meadow Station of the Hartford Electric Light Company. Following up the experimental work done in the Dutch Point Station, the Hartford Electric Light Co. is now installing a mercury vapor turbine which will have a capacity approximately five times as large as any previous mercury vapor turbine installation. This unit, now being installed in the South Meadow Station, will be watched with interest, for it is of such size as to indicate clearly the adaptability of the mercury vapor cycle for use in large steam generating stations.

Prospects for the Future

Taking a look into the future, it seems safe to predict that we shall see:

1. The use of steam at still higher temperatures. We have had considerable operating experience during the last two or three years with steam temperatures ranging from 750 deg. to 900 deg. F., most of this experience being unpremeditated and of short duration and taking place in connection with the initial operation of some of our large steam generating stations. This experience has indicated that we may be able to go to higher steam temperatures with only a reasonable amount of trouble.

Manufacturers are ready to furnish superheaters, valves, and turbines designed for 900 deg. F. total steam temperature. There is a doubt, however, as to whether the metals which are available today will withstand the combined effects of the stresses incident to high steam pressure and a temperature of 900 deg. for extended periods without occasional failures.

2. An increase in the use of pulverized fuel. The trend of pulverized fuel firing will, I believe, be along the lines of using burners which will give a turbulent mixing of the air and coal streams resulting in a reduction in the size of the furnaces. In order that pulverized fuel firing shall be increasingly attractive, it is necessary that the incremental investment incident to this method of firing, as compared to the use of stokers, must be reduced and, for this reason, it is probable that we shall see some worth-while developments along the line of using unit pulverizing mills.

3. Further increases in the size of turbine units and boilers. There will be a tendency, as the loads in connection with our large interconnected systems grow to higher and higher values, to use turbine units of sizes ranging from 10 to 20 per cent of the total system peak load. A careful balance struck between the reduction in investment per unit of capacity, the improved performance and the reduced labor costs on the one hand and the increased investment incident to the additional spare capacity made necessary by use of the larger units on the other hand, will serve to limit the size of turbine units. The more attractive possibilities lie along the lines of using larger units in the boiler house, as there are greater potential savings in investment incident to the use of larger units in the boiler house than in the turbine room.

4. In the main, I believe the most attractive possibilities in steam station design lie, for the next few years, along the lines of a consolidation of the gains which we have already made, the simplification, wherever possible, of our new designs and the adaptation of certain tendencies in design which will permit of reductions in investment with but slight increases in coal consumption per unit of station output.

Factors Bearing on Proper Water Treatment

AN ANALYSIS OF DATA COLLECTED IN THREE PLANTS TO DETERMINE THE MOST IMPORTANT FACTORS TO BE CONSIDERED IN THE TREATMENT OF FEED WATER. BY D. C. CARMICHAEL

IN THE PROPER treatment of water, there are many other factors having an exceedingly important bearing than just a chemical analysis. While a chemical analysis is part of the necessary data, oftentimes a survey of the operating and mechanical conditions combined with the chemical information is partially or altogether overlooked.

Data to be collected of the operating conditions may be classed as follows: Steam pressure, rating, character of load, whether fluctuating or steady, amount of condensate returns as well as the source of the return and temperature of feed water leaving the heater. In

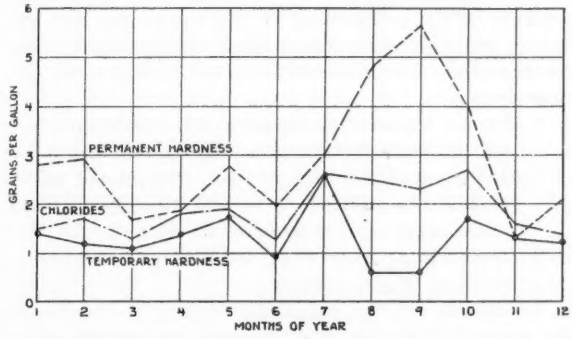


FIG. 1. CHART SHOWING VARIATION IN HARDNESS AND CHLORIDE CONTENT OF RAW WATER OVER A PERIOD OF ONE YEAR

most large generating stations, surface condensers are used and the condensate is supplied from this source, but from the industrial plant, this may not be the case. Oftentimes, condensate is returned from heating systems and closed heaters, where more or less contamination is received, depending upon whether live or exhaust steam is used and from what type of prime mover the steam is being supplied.

From a mechanical standpoint, data on the type of heater, whether open or closed and of sufficient size, if of the open type, to heat all the water for boiler feed purposes to the maximum temperature necessary to drive off the corrosive gases to the atmosphere, name, number and rated horsepower of each type of boiler and the condensers in use, whether surface, jet or barometric.

If a softening system is in active operation, complete information as to the type and size of tanks should be procured. That this is necessary is shown in an investigation, described later, in which a plant had an undersized softener for the amount of water evaporated and the chemicals necessary to advise were those which would give quick reactions and maximum settling efficiency in a minimum length of time; also, information as to the condition of the sand filters when used in conjunction with the softening system.

Investigations were made in a plant having one or more of the factors mentioned entering into the proper conditioning of the water and various reasons, with corrective measures, were advanced. These measures failing to prove successful, the writer was requested to make a detailed investigation of the conditions, to point out the most salient factors governing the conditions in each case and to submit recommendations for correcting the troubles. This article covers investigations made

TABLE I. LABORATORY ANALYSES OF AVERAGE MONTHLY SAMPLES OF BOILER FEED WATER

MONTH	TEMPORARY HARDNESS (Grains per U.S. Gallon)	PERMANENT HARDNESS (Grains per U.S. Gallon)	SODIUM CHLORIDE
January	1.40	2.80	1.5
February	1.20	2.90	1.7
March	1.10	1.70	1.3
April	1.39	1.85	1.8
May	1.74	2.78	1.9
June	.92	1.97	1.3
July	2.60	3.00	2.6
August	.60	4.80	2.5
September	.60	5.70	2.3
October	1.70	3.90	2.7
November	1.30	1.30	1.6
December	1.20	2.10	1.4

in three different plants, two of which were using hot process softeners, and the third internal treatment. The boiler feed supply in each case was river water, whose mineral content in terms of soluble salts was about the average industrial supply. As mentioned above, the raw or river water in the first two plants was passed through a hot process continuous lime-soda ash softener, filtered and used for boiler feed purposes.

PLANT NO. 1

In Fig. 1, the changes of temporary and permanent hardness as well as the chlorides over a period of a

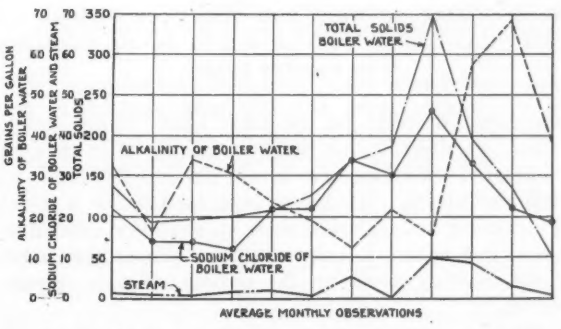


FIG. 2. SHOWING INCREASE IN TOTAL SOLIDS DUE TO DECREASE IN FREQUENCY OF BLOW DOWNS

year for the raw water (boiler feed) are plotted. Table I shows the laboratory analyses of the average monthly samples of boiler feed water. The plant using this water as boiler feed was equipped with a hot process continuous lime-soda softener, but was having a hard, dense calcium sulphate scale. During the writer's investigation, the lime charge was lowered approximately 25 per cent in the course of a week with a 10 per cent increase in soda ash and after four months' close supervision on the softener, all the old scale formations were removed and no indications of any new scale formations after 18 mo. operation.

Occasional conditions of foaming are experienced when the operators do not blow down the required

number of times, as is shown in Fig. 2. This is plainly pointed out in the increase of permanent hardness during the ninth month, as shown in Fig. 1, and the following increase of the total solids on Fig. 2 at the same period. An average sample of trap discharge from the main header contained 9.8 grains of sodium chloride, thus showing the effect of increased concentration of soluble salts in the boiler water.

In all three investigations, a chemical method in place of the throttling calorimeter was used for determining the quality of steam produced. At the various observations, trap discharges were collected and examined for their content of alkaline soda and sodium chloride; thus a trap discharge free of soda and salt would mean 100 per cent dry steam, while those containing these materials indicated contamination proportionate to the percentage of boiler water contained in the trap discharge.

Where wet steam was in this case due to high concentration of soluble salts, the curve of the sodium chloride present in the steam followed the general in-

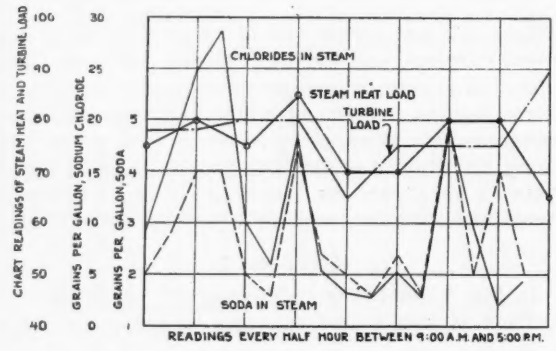


CHART READINGS OF STEAM HEAT AND TURBINE LOAD
GRAINS PER GALLON, SODIUM CHLORIDE
GRAINS PER GALLON, SODA
CHLORIDES IN STEAM
STEAM HEAT LOAD
TURBINE LOAD
SODA IN STEAM
READINGS EVERY HALF HOUR BETWEEN 9:00 A.M. AND 5:00 P.M.

FIG. 3. CHART SHOWING THE EFFECT OF PRIMING OF STEAM HEAT LOAD OF NON-CONDENSING ENGINE COMPARED TO TURBINE LOAD

crease and decrease of the total solids of the boiler water. At present, this plant is making daily tests on the treated water as well as on the boiler water and condensed steam. The water from each boiler is tested for alkaline and chloride salts so that the concentration of the boilers is known; thus a proper regulation of the blowing down by the sodium chloride concentration.

This investigation points out that a study of operating conditions combined with the proper control of the softener brought about a substantial saving in the boiler operations.

Plant No. 2

Another investigation which shows the importance of obtaining operating and mechanical data for proper water treatment was made in a western plant. This particular plant was equipped with a continuous hot process lime-soda softener and filters after the softener. The boiler equipment consisted of 12 386-hp. Stirling boilers, carrying 150 lb. steam pressure. On account of the condensers being jet and barometric, practically 100 per cent make-up water was used, which at times meant an overload on the softener. Hard scale was encountered in the boiler tubes and steam drum as well as a plastic deposit on the turbine blades.

Two problems were considered at this plant for solution:

1. Softener control.
2. Priming of boilers.

Softener

The salient points in the control of the softener at this plant were to correct the chemical treatment and to produce clear softened water. Based on a daily raw water consumption of approximately 3,000,000 lb., the softening equipment was operated at an average overcapacity of 12.5 per cent. On a peak load, this overrating was as high as 100 per cent, at which time the suspended matter played an important part. On account of this over-rating, the suspended matter resulting through the precipitation of the hardness did not have sufficient time to settle and in consequence, the largest portion of this precipitate was carried over to the filters, resulting in the overloading of this equipment and materially affecting their functioning and capacity. For the correction of this condition, three factors came into consideration:

1. Proper chemical treatment for the maximum precipitation of the scale-forming ingredients.
2. More rapid settling of the precipitated solids within the softener to relieve the filters of the large share of this work.
3. Maintaining a treating temperature as close to 212 deg. F. as possible.

To achieve the first-mentioned object, the treatment was changed from lime to caustic soda on account of the high temporary hardness of the water, thus decreasing

TABLE II. READINGS OF STEAM CONSUMPTION OF TURBINE AND RECIPROCATING ENGINE SUPPLYING STEAM HEAT

	TURBINE LOAD		STEAM HEAT LOAD	
TIME	METER READING	POUNDS OF STEAM PER HOUR	METER READING	POUNDS OF STEAM PER HOUR
9:00 A.M.	78	28,470	75	28,200
10:00 A.M.	78	28,470	80	30,080
11:00 A.M.	80	29,200	75	28,200
Noon	80	29,200	85	31,900
1:00 P.M.	65	27,725	70	26,320
2:00 P.M.	75	27,375	70	26,320
3:00 P.M.	75	27,375	80	30,080
4:00 P.M.	75	27,375	80	30,080
5:00 P.M.	90	32,850	65	24,440

the amount of precipitated sludge. Daily tests were followed more closely, so that the proper changes on the amount of chemicals were made when necessary.

Although a change in chemicals did decrease the amount of precipitated solids, what remained was of a fine nature and remained suspended for the most part consequently passing on to the filters. It then became quite obvious that some additional treatment was necessary which would coagulate these fine particles into larger ones and thus facilitate more rapid settling within the softener. This was accomplished by the use of ferrous sulphate from which ferrous hydrate would be precipitated.

A temperature of 212 deg. F. mentioned under third heading was necessary for two reasons. First, the chemical reactions for the precipitation of the scale-forming material proceed at a much more rapid rate at high temperatures. Second, as time was an important consideration, the higher temperature was necessary in that the reactions will occur almost instantaneously at

this temperature, allowing a greater time for the settling period. It was also found that, due to the water being lighter at the mentioned temperature, less resistance was offered to the falling particles of sludge, which hastened the settling period.

In order to increase the efficiency of the filters, new sand was recommended and ample provision made for properly back-washing the filters, the effectiveness of which were determined by the drop in pressure through the filtering medium.

Priming

The problem of priming was extremely serious and the following factors entered into this condition:

1. Suspended matter.
2. Concentration of total soluble solids.
3. Character of load.

Suspended Matter

Inasmuch as finely divided particles of mud, sludge, etc., form nuclei for the generation of steam bubbles, it was apparent that when these particles existed in large quantities, the generation became very free with the formation of bubbles on the surface of the water. While this effect is commonly noted as foaming, its effects were no different from that of priming; thus both effects were classed under priming.

Elimination of these finely divided particles is best brought about by the proper functioning of the softener and filter. Where the hardness is precipitated to the maximum amount possible and the finished water filtered, the accumulation of finely divided particles is reduced to a negligible quantity.

Total Concentration of Soluble Solids

As this was, perhaps, the most important single consideration of the priming problem, immediate steps were taken for the reduction of the soluble solids. This was accomplished by more frequent blowing down, using the salt test as a guide.

That this reduction in total solids was effective is shown during the observations over a period of three days, which were as follows:

First Day's Observations

Boiler Number	Soda	Salt
	(Grains per U. S. Gallon)	
2	.4	36.0
3	.8	34.0
5	4.8	36.4
6	.8	5.6*
10	4.8	36.4
11	3.6	24.0
12	4.8	27.2
Average	2.8	32.3

*Boiler No. 6 was not included in the average on account of the concentrations being so low that they would not affect any foaming condition.

Condensed Steam	Soda	Salt
	5.2	25.0

Condensed Steam in per cent boiler concentrations—77.4 per cent.

The blow-downs were increased from 3 to 6 times during the next 24 hr. so as to bring the boiler water concentrations below the priming point.

Second Day's Observations

Boiler Number	Soda	Salt
6	6.8	37.6
7	5.6	41.6
9	6.2	58.4
10	1.8	30.4
11	2.0	6.0*
Average	4.4	34.8

*Boiler No. 11 was not included in the average on account of the concentrations being so low that they would not affect any foaming condition.

Condensed Steam

Time	Soda	Salt
9:00 a. m.	2.0	8.8
9:30 a. m.	2.8	16.8
10:00 a. m.	4.0	24.8
10:30 a. m.	4.0	28.6
11:00 a. m.	2.0	10.0
11:30 a. m.	1.6	6.0
Noon	4.4	18.4
12:30 p. m.	2.4	5.2
1:00 p. m.	2.0	3.2
1:30 p. m.	1.6	2.8
2:00 p. m.	2.4	5.2
2:30 p. m.	1.6	2.8
3:00 p. m.	4.8	19.2
3:30 p. m.	2.0	9.2
4:00 p. m.	4.0	2.0
4:30 p. m.	2.0	4.4
Average	2.7	10.4

Condensed Steam in per cent boiler concentrations—30.7 per cent.

The Condensed Steam test for the second day showed very high, indicating that the priming had not decreased to any extent, on account of the increased number of blow-downs not having had time for effect.

Third Day's Observations

Time	Boiler Number	Soda	Salt
10:15 a. m.	2	1.6	19.2
	3	1.2	24.8
	5	2.4	30.8
	6	2.0	22.8
	7	1.6	30.8
	8	.8	12.0
	10	.4	19.6
	11	.8	27.2
	12	1.6	32.0
9:00 p. m.	2	4.4	26.2
	3	5.4	33.0
	5	6.6	29.2
	6	4.6	24.4
	7	2.4	25.4
	8	5.0	23.0
	11	3.2	32.8
	12	1.2	16.6
Average for both tests		2.7	25.3

Condensed Steam Time	Soda	Salt
9:00 a. m.	1.2	2.0
9:30 a. m.	.8	2.4
10:00 a. m.	.6	1.6
10:30 a. m.	.8	1.8
11:00 a. m.	.8	1.6
11:30 a. m.	.8	1.2
12:30 p. m.	.8	.8
1:00 p. m.	.8	.8
1:30 p. m.	.8	.8
2:00 p. m.	.8	.8
2:30 p. m.	.8	1.2
3:00 p. m.	.8	1.2
3:30 p. m.	1.0	1.2
4:00 p. m.	1.0	.8
4:30 p. m.	.6	.8
5:00 p. m.	.8	1.2
5:30 p. m.	1.2	.6
6:00 p. m.	1.2	1.0
6:30 p. m.	.8	.8
7:00 p. m.	1.0	.8
7:30 p. m.	1.0	1.2
8:00 p. m.	1.2	1.0
8:30 p. m.	1.2	.8
9:00 p. m.	.8	1.0
9:30 p. m.	1.2	1.2
10:00 p. m.	1.2	1.4
10:30 p. m.	1.0	1.2
11:00 p. m.	1.2	1.4
Average	1.04	1.17

Condensed steam in per cent boiler salt concentration—4.6 per cent.

The quality of condensed steam was very good as compared to the first and second day's tests, showing the effect of increased blow-downs. The fact that the salt concentrations of the condensed steam in terms of boiler concentrations were reduced from 77.4 per cent to 4.6 per cent is sufficient evidence that the lowering of the concentrations was justified. This improvement was made with a 22 per cent reduction in the boiler concentrations.

Character of Load

The effect on priming of the steam heat load of the non-condensing engine compared to the turbine load is shown in Fig. 3. The pounds of steam per hour as indicated by the meter reading on Fig. 3 is shown in Table II. This investigation shows the importance of proper data being had on the softener as well as of the operating conditions, pertaining to the rating and character of load.

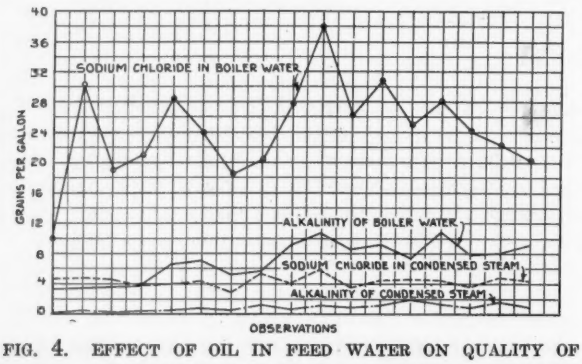


FIG. 4. EFFECT OF OIL IN FEED WATER ON QUALITY OF STEAM. OIL PRESENT IN CONDENSATE RETURNS. MAKE-UP, POND AND CITY WATER

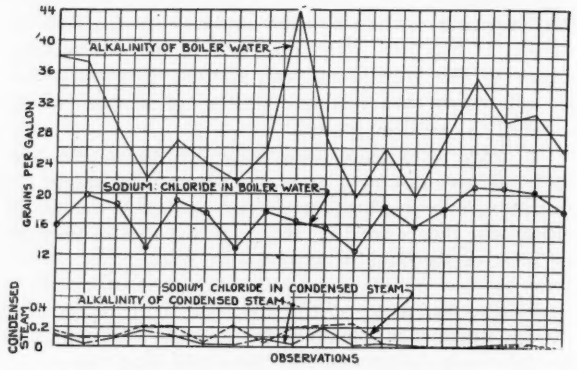


FIG. 5. CHART SHOWING QUALITY OF STEAM. NO OIL CONTAMINATION. MAKE-UP POND WATER

Plant No. 3

This investigation was made in an industrial plant having trouble with foaming and scale conditions. The boiler equipment consists of 8 boilers, ranging from 260 to 400 hp., fired at 125 to 150 per cent rating. Load conditions were steady, the steam being used for power and process work. The power was generated by reciprocating engines from which the exhaust steam was used directly for heating in the process work. The lines carrying the exhaust steam were not equipped with oil separators so that the condensate returns from the different heating processes carried considerable amount of compound oil to the hot well. At this point, the make-up consisting of a mixture of pond and city water was introduced. The returns from traps and steam separators were, also, fed into the hot well, thus increasing the contamination in the feed water when the boilers carried over soluble material in the steam. The greatest cause of foaming was the compound oil returned to the hot well. The content of oil was sufficient to show one to three grains per gallon of oil in samples of feed water collected from the discharge of the boiler feed pump. Figure 4 pictures the effect of oil on the quality of the steam in terms of the soda and sodium chloride carried over with the boiler water. Fatty acids which are present in compound oils react with soda ash for treating the hardness of the water and thus form soap which gives rise to severe foaming conditions.

The writer has noted in various observations that as long as sufficient hardness is present in the boiler water, the soap formed by the fatty acids is neutralized; but

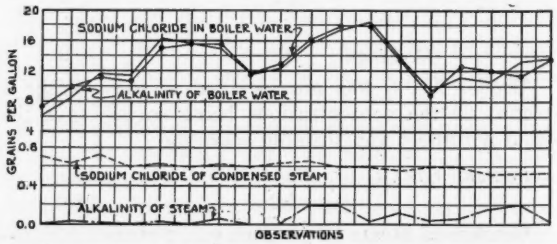


FIG. 6. CHART SHOWING QUALITY OF STEAM. NO OIL CONTAMINATION. MAKE-UP, CITY WATER

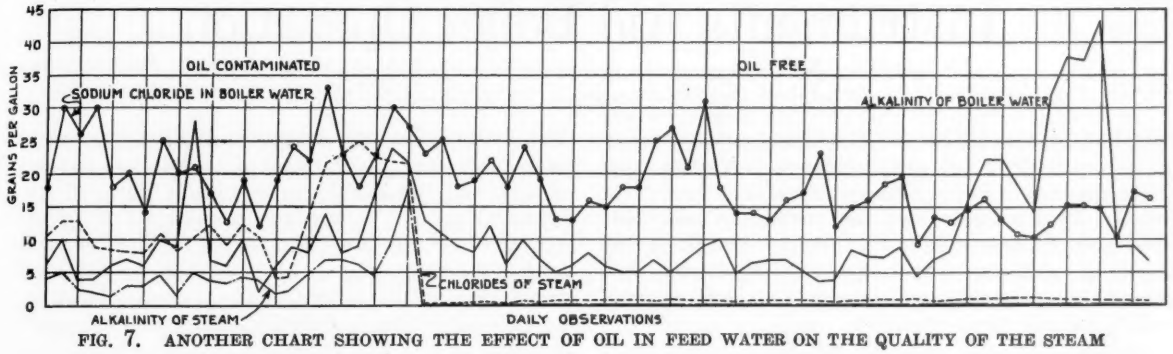


FIG. 7. ANOTHER CHART SHOWING THE EFFECT OF OIL IN FEED WATER ON THE QUALITY OF THE STEAM

as soon as the soda treatment is increased in sufficient quantities to precipitate the hardness, foaming will immediately take place.

The question of concentration of soluble solids arose in connection with the foaming condition and in order to show that this does not have any effect on the condensed steam, tests were made on two plants nearby, one using city water and the other pond water as make-up. These two tests are shown in Figs. 5 and 6, indicating that little trouble was being encountered with soluble material being carried over in the steam.

TABLE III. RESULTS OF TESTS SHOWING EFFECT OF OIL GAINING ENTRANCE TO BOILER

OBSERVATION	CONDENSED STEAM (Average)			BOILER WATER	
	Grains - Soda (FEED WATER OIL-CONTAMINATED)	Grains - Salt	% Boiler Concentration	(Grains per U.S. Gallon) Alkalinity	Salt*
1	4.0	10.4	57.8	76.0	18.0
2	4.8	12.6	45.0	10.0	30.0
3	2.4	12.6	46.5	4.0	26.0
4	2.0	8.9	29.7	4.0	30.0
5	1.4	8.4	46.7	6.0	18.0
6	3.1	8.2	41.0	7.0	20.0
7	3.0	8.0	57.2	6.0	14.0
8	4.6	11.0	44.0	10.0	25.0
9	1.6	8.4	42.0	9.0	20.0
10	5.1	10.4	49.5	28.0	21.0
11	3.9	12.3	72.2	7.0	17.0
12	3.3	9.1	74.0	6.0	12.6
13	4.4	12.4	65.1	19.0	19.0
14	3.8	10.2	85.0	2.0	12.0
15	1.8	4.0	21.1	6.0	19.0
16	2.1	4.3	17.9	9.0	24.0
17	4.5	13.5	61.3	8.0	22.0
18	5.8	21.8	66.1	14.0	33.0
19	7.0	23.1	99.0	8.0	22.0
20	6.2	25.0	--	9.0	18.0
21	4.5	22.5	--	17.0	23.0
22	9.4	21.8	72.6	24.0	30.0
23	17.8	21.5	79.8	22.0	27.0
	(FEED WATER OIL-FREE)				
24	0	.2	.8	13.0	23.0
25	0	.2	.8	11.0	25.0
26	0	.2	1.1	9.0	18.0
27	0	.5	2.6	8.0	19.0
28	.1	.5	2.2	12.0	22.0
29	.2	.3	1.66	6.0	18.0
30	0	.5	2.5	10.0	24.0
31	.1	.5	2.6	7.0	19.0
32	0	.7	5.3	5.0	13.0
33	.1	.7	5.3	6.0	13.0
34	0	.6	3.7	8.0	16.0
35	0	.6	4.0	6.0	15.0
36	0	.6	5.3	5.0	18.0
37	0	.8	4.4	5.0	18.0
38	0	.6	2.4	7.0	25.0
39	0	1.0	3.7	5.0	27.0
40	0	.7	3.3	7.0	21.0
41	0	.6	1.9	9.0	31.0
42	0	.7	3.8	10.0	18.0
43	0	.5	3.5	4.8	14.0
44	0	.7	5.0	6.8	14.0
45	0	.7	5.3	6.8	13.0
46	0	.7	4.3	6.8	16.0
47	0	.8	4.7	5.1	17.0
48	0	.7	3.0	3.6	23.0
49	0	.5	4.2	3.6	11.8
50	0	.6	4.0	8.4	14.8
51	0	.6	3.8	7.4	15.8
52	0	.7	3.8	7.2	18.4
53	0	.6	3.1	8.7	19.4
54	0	.7	7.6	4.2	9.2
55	0	.5	3.8	6.8	13.2
56	0	.6	4.8	8.1	12.5
57	0	.6	4.1	16.0	14.4
58	0	1.0	6.2	22.0	16.0
59	0	.6	4.6	22.0	13.0
60	0	.6	5.6	17.0	10.6
61	0	.7	6.8	13.6	10.2
62	0	.7	5.8	32.0	12.0
63	0	.8	5.3	38.0	15.0
64	0	.8	5.3	37.0	15.0
65	0	.6	4.1	43.0	14.5
66	0	.7	7.0	8.4	10.0
67	0	.7	4.1	8.6	17.0
68	0	.6	3.7	6.1	16.0

On account of the low content of soda in the boiler water due to the foaming trouble, heavy scale was had. As soon as the oil condition was corrected by a filter and alum coagulant, a larger amount of soda could be used, which reflected itself in the improved scale conditions.

Figure 7, while having no bearing on the investigation of plant No. 3, shows the effect of oil-contaminated and oil-free feed water.

The change in soluble material in the steam took place in a very few days, as is pointed out through the daily tests. A sample of the condensed steam during one of the heavy foaming conditions analyzed as follows:

Sodium Carbonate	2.97 grains
Sodium Bicarbonate	2.02 grains
Sodium Chloride	6.30 grains
Sodium Sulphate	15.10 grains
Organic Matter and Suspended Matter	13.60 grains
Total Solids	40.00 grains

The daily readings over a total observation period of 64 days is shown in Table III.

This third investigation pointed out that it is very necessary to take into consideration the source of all condensate returns, especially in the industrial plant, where more or less contamination is present.

Conclusions

From the tests stated herein, it is evident that the operating and mechanical data should be taken into consideration along with the chemical factors bearing on the proper water treatment.

In most plants of any size, the mechanical department handles certain conditions pertaining to the boilers and the chemical department the analyses and testing of the water. The chemist has certain common terms familiar to him, but foreign to the mechanical engineer and the same with the terms of the mechanical engineer, so that the conditions from a mechanical standpoint may be told to the chemist and mean nothing and the same applies when the chemist explains the analyses to the mechanical department.

If an investigation can be made by the same engineer and all factors taken into consideration, much better results can usually be obtained with the water treatment.

Reports of stocks of coal on hand indicate that, even with a strike in the union mines, no coal shortage will occur for at least 4 mo. Prices will, however, rise of course and local scarcity may be encountered in some sections. Wise provision by power plant managers is in order to insure adequate fuel supply.

Instruments Aid Boiler Operation

Discussion of Need of Securing Accurate Operation Data and Benefits Derived Thereby. By Charles H. Adams*

THE ACTUAL EFFICIENCY of any piece of boiler apparatus or in fact any machine, is dependent upon the measure of its operation and control. The human equation is therefore a dominant factor. In order that the operator may intelligently handle or direct the operation of boiler plants, proper instruments well adapted to the specific conditions are provided to permit him to analyze those conditions.

Instruments are necessary. When a doctor visits a person who is ill, about the first thing that he does is to look at his tongue, feel his pulse, take his temperature, etc., and while he is doing this he is also asking what his patient has been eating; how much and all about it. The point is that in order to diagnose the case properly the boiler operator must have instruments and information. Probably the first thing that a fireman will do is to look at the fires. He will also want to know the stack temperature, feed water temperature, flue gas analysis, heating value and other characteristics of the fuel, amount consumed and the draft conditions. Without the necessary proper instruments he would be unable to obtain this data.

Instruments should be selected to suit the size of plant, the conditions of operation and the operator. They should be of a kind that can be understood by the person who is to operate and read them. Instruments that are placed in dirty, secluded or inconvenient places soon lose their significance. Indistinct instruments are not very desirable and inaccessible instruments are worse than having none at all. Distinctness and simplicity of design are very desirable. Practical considerations should be carefully used in the selection of instruments. You would hardly order a 4-in. pressure gage to be placed on a boiler 25 ft. above floor level. It would register the pressure, but who would try to read it. It would be well if the working pressure would be marked on the upper center of the dial. The function of all instruments is to better efficiency, otherwise we could feel content with a pressure gage and a water column.

Instruments Selected in Order of Importance

Instruments of major importance should be selected first. It is a common occurrence to order a lot of new fangled instruments before the old instruments, which have been installed, have been understood by the operator and therefore their usefulness or lack of usefulness, determined. Under these circumstances, more expense is added and greater ignorance established unless the new instrument is simpler and more easily understood by the operator.

Of the more important boiler instruments two, it is agreed, are vital to operation and safety. These two are the water column and pressure gage. We should have an instrument board if it is convenient to provide it. The first instrument which I think should be given consideration is that used for weighing or measuring fuel. Regardless of the kind of fuel, this instrument should never jam up. It should at all times be absolutely accurate. It is essential to compare firemen's records, and this should be accurately done. Correct figures from day to day give a check on the plant's operation. If we know the amount of fuel consumed every 24 hours, we can, by studying the best day's records and results, determine the approximate cause of a good and bad day's operation and guide our practices to conform with the results of this investigation provided reliable fuel measuring devices have been installed.

Next in importance, is the instrument for determining the quantity or weight of feed water. There are many methods in use, but from my experience, I believe that the Venturi meter or tube is the most reliable, although there are other instruments which are reliable. By checking the water fed to the boilers we have our first real step toward figuring boiler efficiency, i. e., evaporation per pound of coal. It is more common to note the evaporation by periods rather than daily. By noting the cause responsible for under evaporation we have the first guide, in terms of evaporation, for comparison and to reduce fuel bills.

Weighing Fuel and Water, Vital Requirements

Following the subject of weighing fuel and water we should consider the exceedingly vital question of how to determine accurately the amount of air which is necessary to support combustion. In an off-hand way we may consider air as the cheapest commodity that we are forced to use, but when it comes to boiler practice we have to believe differently. We see that it is not cheap, hence the need of a good dependable draft gage. There is some certain amount of draft that will burn the fuel at hand most efficiently. The amount of draft required depends upon the nature of fuel that is being used.

There is a definite relation in every instance between fuel resistance, draft and load, and the relations can only be found in any given case by actual tests, hence the rule to follow is: Use the draft that will produce complete combustion with a minimum amount of air while maintaining the steam pressure. Draft should be measured at the furnace and not under the damper because the draft applied to the fuel determines the rate of combustion. It is sometimes important to know the draft resistance or draft loss through the boiler, but this has no effect on combustion provided there is draft enough in the furnace to provide efficient combustion. The skilled fireman will watch the draft gage as closely as he watches the steam and water gages and fire by it. There should be a draft gage on each furnace for the same reason that there should be a water gage on each boiler. The cost of draft gages is insignificant. My selection would be the indicating type of draft gage because its reading is clear and cannot be mistaken.

The next selection in order would be a recording thermometer for the flue gas but it is useless to have a recording thermometer unless you are provided with a

*Chief Engineer, Columbus Electric and Power Co., Columbus, Georgia.

pyrometer for use as a check. Our greatest loss is stack loss. Keep a thermometer in the stack and it will pay good dividends. Everybody knows that to keep heat out of the stack means to keep fuel in the storage.

Co-ordination of Observations Indicates Procedure

This brings us to our first co-ordination of observations. The amount of air and the resulting degree of heat in the flue gas are in a definite ratio. Increase the air and the stack temperature will rise. Excess oxygen means that somebody is trying to thaw out the moon.

We now have a check on the quantity of air and the temperature as recorded in the stack. If we consider these two together, we come to another check, namely CO_2 determination. The CO_2 recorder should be employed in any kind of boiler or plant, regardless of whether you are using a boiler, cook stove, boiler furnace or internal combustion engine. It makes no difference what you are burning, whether it be coal, wood, oil, gas, tar, tan bark or "buffalo chips" you nevertheless need gas analysis.

An evaporative test is very necessary and should be run occasionally for the edification of the personnel and as a check on all instruments in order to provide accurate data for use in reports to superiors.

Flue gas analysis presents combustion efficiency in direct terms. The highest efficiency is attained when we get complete combustion with a minimum air supply. In doing this we may get a temperature high enough to melt the brickwork of the furnace. There are then, limits to the desirable quantity of CO_2. What is desired is the best overall percentage of CO_2 that it is practicable to maintain. For every condition, whether the fuel used is in a solid, liquid or gaseous state; whatever the relation of volume of the combustion chamber to the grate area; whatever the method of firing or what the available draft, etc., there is a certain percentage of CO_2 that will give maximum net combustion efficiency.

Combustion analysis indicates the efficiency of boiler furnaces, neglecting the carbon that is being wasted in the ash and the heat that is being radiated from the furnace. It shows how much if any carbon monoxide is passing off with the flue gases and how much if any excess air is entering. It shows also just what draft we should employ to insure the best efficiency, provided we have a properly installed draft gage with which to measure the draft. The amount of draft considered with relation to the desired percentage of CO_2 when the load is satisfactorily met, is the draft to be employed.

Our next instrument should be a recording thermometer to be used for the feed water. When it is realized that a 10 to 12 deg. variation means one per cent variation in efficiency, the importance of the use of this instrument is obvious. The recording thermometer comes in handy also when calculating evaporative tests and for future reference. For the same reasons we should have a recording steam pressure gage and a recording thermometer on the steam line. Another advantage experienced when proper instruments are installed is that of adequate mechanical control.

There are three appliances that are essential to efficient operation. In the order of their importance they are:

1. Damper regulators.
2. Feed water regulators.
3. Steam flow meters.

Especially where coal is being fired, is a damper regulator essential. It is an instantaneous check on the furnace bed, it is the dispenser of air, and a grim watchdog on the fuel supply.

A good feed water regulator is the main reservoir of the steam system, a storer or dispenser as the case requires and as such it is an improvement over hand regulation. However, a feed-water regulator is a regulator and does not in any way eliminate the necessity of watching the water. Firemen should be shown, however, that a feed-water regulator does not necessarily decrease the necessity of water level observations.

Steam flow meters are necessary if there is more than one boiler. If only one boiler is used a flow meter is not required. Every boiler has its most economical rate of operation. This best rate is established by actual test. A steam flow meter indicates definitely when the predetermined point is reached. When one or more batteries of boilers are being run we are able to operate all the boilers except one or possibly two, depending on load and load conditions, at their most efficient ratings. The other boiler may be used effectively as a booster to meet varying load conditions.

More Light, Better Work

By William Sibley

GOOD LIGHTING not only makes for cheerful and comfortable surroundings but increases output and reduces waste. Improvements in lamp construction have doubled the illumination for a given energy cost so that, although it is natural to feel that the lighting cost should be kept to a minimum, the expense of good lighting is now less than was that for inadequate lighting a few years ago.

Inside frosted lamps do away with glare and are easily cleaned, but attention should be given to using proper reflectors as those designed for old style lamps often do not give the best results with the newer forms. The tin cone reflector is entirely unsuited for 90 per cent of the lamps in use today and should be replaced with reflectors scientifically designed to give best lighting efficiency with modern high intensity filament lamps.

Reliable authorities state that good lighting will increase production 15 per cent at an increase in cost of only 2 per cent and, in addition accidents, which might cost many times the lighting cost, will be eliminated. Good lighting is a good investment and ample illumination returns big dividends.

A new method of insulating pipe was recently described by Engineer E. Schmidt, Danzig, reports the VDI-Nachrichten of Feb. 9, 1927. Aluminum leaves of 0.03 mm. thickness are held to the piping by means of supporting rings. The leaves are placed concentric and one cm. apart. The insulation which stands up to 500 deg. C., is covered with a coat of sheet plate to protect it. The heat losses reported are extremely low. The method reduces also the weight of the insulation. For pipe bends, aluminum leaves of 0.007 mm. are recommended.

Condenser Performance Improves Steadily*

REDUCTION IN SURFACE, NEW METHODS OF TUBE PACKING AND CLEANING, PROVISIONS FOR DEAERATION, FORM SOME OF THE PRINCIPAL FACTORS IN RECENT DEVELOPMENTS

DURING the past few years a notable reduction has been effected in the square foot of condensing surface installed per kilowatt of capacity, according to the condensing equipment report of the N. E. L. A. The

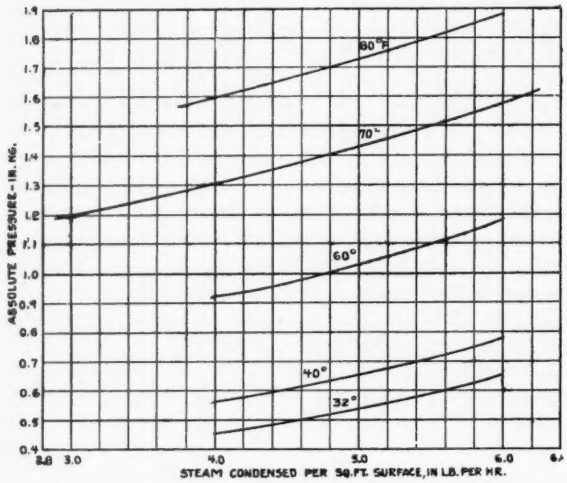


FIG. 1. SHOWING THE POUNDS OF STEAM CONDENSED PER SQ. FT. OF SURFACE AS RELATED TO ABSOLUTE PRESSURE FOR DIFFERENT INLET CIRCULATING WATER TEMPERATURES FOR SEVERAL INSTALLATIONS

chief reason for this lies in improved turbine water rates and bleeding for feed water heating. Improvement in condenser design has also been made and in some cases which have been investigated, it has been found that parts of the surface perform very little work and the removal of tubes has resulted in improved vacuum.

In most existing installations, laning is the only expedient for opening up the inner parts of the tube. In some of the newer designs, however, graduated tube spacing, improved schemes of laning and grouping of tubes is used to increase the heat transfer and decrease cooling of condensate.

ARRANGEMENT OF SURFACE MORE IMPORTANT THAN AMOUNT

The most effective condenser for a given duty is not necessarily the one which contains the greatest amount of surface, but is rather the one in which the proper amount of surface is so arranged that all of it is accessible to the steam, moreover a reduction in the amount of surface does not imply a smaller sized shell.

Examinations of recent condenser installations show an increasing tendency toward the use of duplicate auxiliaries, each motor driven. The tendency is to limit the number of circulating pumps for condensers to two, in order to increase the pump efficiency and keep the first cost low.

Two circulating pumps, each driven by either motor or turbine for independent sources of energy are considered ample protection against outage of the main unit. The arrangement of condenser with divided water box and two circulating pumps is becoming popular, as it permits cleaning of the condenser without shutting down the unit. Both variable speed traveling mechanisms or constant speed motors wound for two stage speed are used for circulating water pumps in the majority of installations. A few operators take advantage of lower cooling water temperatures by running only one circulating pump during the cold season of the year, but the majority prefer to run both pumps throughout the year and to reduce their speed during the cold water season.

Practically all installations have duplicate condensate pumps driven by constant speed motors or steam turbines, using possibly independent sources of power and, in one instance, the use of a vertical condensate pump is reported.

VARIABLE OPERATION OF HOTWELL PUMPS, BEST

While the simplicity of the constant speed hotwell pump has led to its wide use, it is not the correct drive

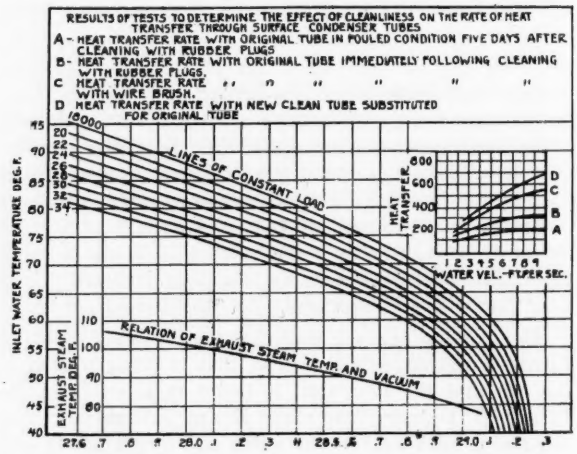

RESULTS OF TESTS TO DETERMINE THE EFFECT OF CLEANLINESS ON THE RATE OF HEAT TRANSFER THROUGH SURFACE CONDENSER TUBES
A - HEAT TRANSFER RATE WITH ORIGINAL TUBE IN FOULED CONDITION FIVE DAYS AFTER CLEANING WITH RUBBER PLUGS
B - HEAT TRANSFER RATE WITH ORIGINAL TUBE IMMEDIATELY FOLLOWING CLEANING WITH RUBBER PLUGS.
C HEAT TRANSFER RATE " " " " " " WITH WIRE BRUSH.
D HEAT TRANSFER RATE WITH NEW CLEAN TUBE SUBSTITUTED FOR ORIGINAL TUBE
LINES OF CONSTANT LOAD
INLET WATER TEMPERATURE DEG. F.
HEAT TRANSFER
WATER VEL. - FT. PER SEC.
EXHAUST STEAM TEMP. DEG. F.
RELATION OF EXHAUST STEAM TEMP. AND VACUUM

FIG. 2. PERFORMANCE CURVES FOR DETERMINING PROPER TIME FOR CLEANING CONDENSER

when variable volume and discharge head is considered. The pump must, of course, be designed for a maximum volume and head and thus, when handling low quantities of condensate with a correspondingly lower discharge head, the hotwell is drained and gravitation occurs. This results in lower efficiency and sometimes damages the pump.

Theoretically the correct way to operate the hotwell pump is to vary its speed in accordance with the amount of water handled. Several devices have been designed to accomplish this by means of water level in the hotwell and successful installations are reported. It is believed that variable speed hotwell pumps will find wider use in the future.

Steam jet air ejectors are by far the most widely used equipment for air extraction, because of their reliability, low first cost and small space requirements.

*Abstracted from Jan., 1927 Report on Condensing Equipment submitted by Prime Movers Committee, N. E. L. A.

Installations using steam jet air ejectors usually have two or more sets; in one instance as many as six were used. Two stage air ejectors with inter and after condensers are almost universal; the majority of installations using condensate from the hotwell, in the inter and after condensers, while some have a small amount of added surface with raw water circulation for starting.

Where hydraulic vacuum pumps are used for air extraction, the apparatus usually consists of two circulation water pumps driven by constant speed motors. Reciprocating drive vacuum pumps are again receiving consideration from operating engineers because of their low power consumption. These pumps usually employ a variable speed drive in order to take full advantage of the low power consumption.

There are a few instances where steam jet air ejectors are used in parallel with either reciprocating dry vacuum or hydraulic vacuum pumps. Air metering devices of the orifice type are frequently provided for indicating the discharge from the air extraction equipment.

Temperature of Circulating Water, Big Factor

Circulating water temperature has a considerable effect upon the condensing surface necessary and Fig. 1 has been prepared from operating data to show this effect.

One company reports a 1-in. difference in vacuum for full load where circulating water changed from 83 to 55 deg. F., while another reports a 2½-in. difference for temperature changes of from 85 to 33 deg. F.

Operation of a condenser cannot well be checked without a knowledge of the approximate amount of air

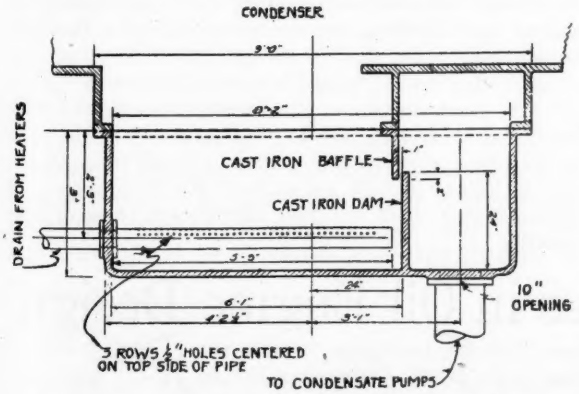


FIG. 3. SPECIAL DEAERATING HOTWELL USED ON 25,000 SQ. FT. CONDENSERS

leakage. Accordingly, in most of the new installations now going into service, air meters or flow indicators are installed at the discharge of the air removal apparatus. These devices, while not very accurate, give relative and approximate indications of the amount of air being withdrawn from the condenser and are a great assistance to operation. When calibrated with a gasometer by a manufacturer, or by the user, its readings will be sufficiently accurate for the purpose.

Difficulty of getting complete information on condenser operation is proved by the fact that the average small or medium sized plant does not keep careful records of the performance of its condensing equipment, with the result that best economies are not realized. Allowable condenser leakage depends upon the conditions and character of the circulating water. For plants located on fresh water lakes and rivers where the water does not carry an exceptional amount of dissolved solids, the general practice is to hold the leakage to less than ½ per cent. For sea water, spray pond, or river water with large quantities of dissolved salts, the leakage must be more carefully watched, and is in some instances kept as low as 0.1 per cent or less.

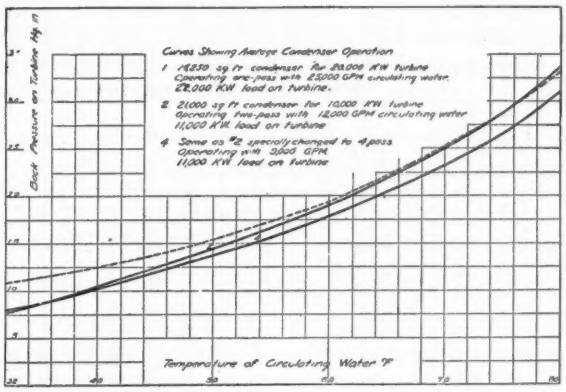


FIG. 4. CURVES SHOWING COMPARISON OF SINGLE, 2-PASS, AND 4-PASS CONDENSER OPERATION

The use of some types of conductivity meters having recording or graphic features permanently installed in the condensate line is reported by a majority of the plants, while others use portable sets to determine the conductivity of samples drawn periodically from the line.

Tube Cleaning of Prime Importance

Tube cleaning is of prime importance, and affects directly the heat transfer and the vacuum. Outside tube cleaning has not been found necessary except in very unusual cases, and while the rubber plug, spring wire plug and other cleaners of this type are used in the majority of plants, hand blasting, acid and baking have been used to meet unusual conditions. The proper time for cleaning condensers is indicated by Fig. 2.

Corset lace packing impregnated with paraffine is reported in use by the greater percentage. Tubes rolled at one end are common, while condensers with tubes rolled in both ends are being installed or have been ordered. Most of the latter have one fixed tube sheet and one floating, although after considerable experimental work, a 30,000-sq. ft. condenser with tubes rolled in both ends and fixed tube sheet has been ordered.

Considerable experience has been obtained recently with belled inserts, belled tube ends, ferrules and in inserts to prevent disturbance of the stream at the entrance of the tubes, resulting in liberation of oxygen and other gases from the water, which cause a corrosive action at this point. Material for the construction of condenser tubes, particularly for acid water has been receiving considerable attention and a plant now being built in Pennsylvania where the water contains considerable sulphuric acid will install copper tubes in two condensers. The tubes of one of the condensers will be painted with a bitumastic enamel, prepared especially for this purpose.

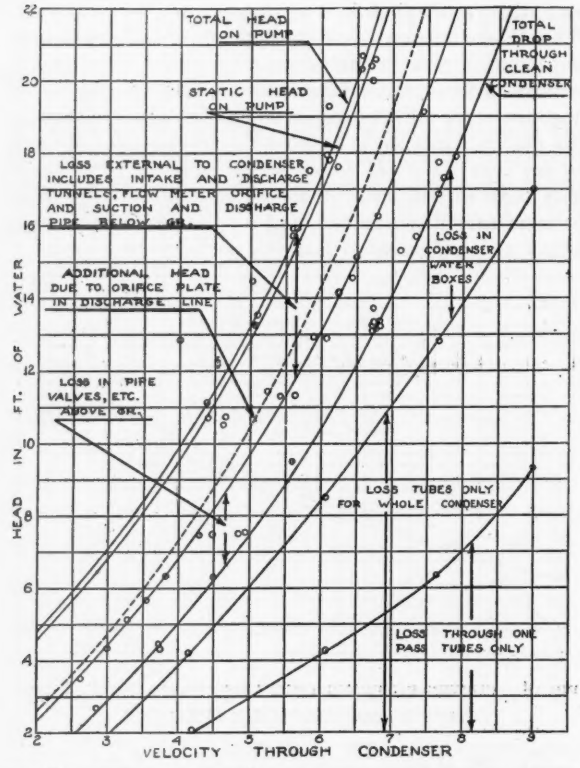


FIG. 5. RESULTS OF TESTS TO DETERMINE FRICTION LOSSES THROUGH CIRCULATING WATER SYSTEM AT LONG BEACH PLANT—SOUTHERN CALIFORNIA EDISON CO.

Some reduction in heat transfer, and consequently in the vacuum, will result from the application of this coating. Just how much this will be, depends on the thickness of the coating and the cleanliness of the metal surface before application. One investigator has stated that it may be as much as ½ in. of mercury.

Deaeration Aids Condenser Operation

Special deaerating hotwell design is used in two 25,000-sq. ft. condensers as shown in Fig. 3. The drains from the bleeder heaters enter the hotwells through the perforated pipes and the drips contain sufficient heat to cause violent ebullition. When these hotwells were first installed the vertical baffles projected downward over the cast-iron dam. Approximate oxygen determination showed about 0.25 c.c. to the litre. This is due to the absorption of oxygen by the water when flowing over the dam. The vertical baffle was then installed and as a result the oxygen in the feed water has been reduced to a negligible quantity. Curves in Fig. 4 show the results obtained for the single pass, two pass and four pass operation of condensers. The curves of the two pass and four pass operation were made on the same condenser, which was originally designed for two pass operation. All of these curves are made on the condensers under regular operating conditions and thus show the best possible results with perfectly clean tubes. Three companies have independently carried on exploration tests on large sized condensers to determine the extended activity for the various portions of the surface. These investigations arrive at a general conclusion that considerable benefit will result by removing inactive tubes and providing easier access for the steam to the inner condenser surface. Tests carried on at Hell Gate show that there is a reversed flow in some of the tubes due to the effect of the water in the return box as it flows from the first to the second pass.

Considerable diversity of opinion still exists as to the kind of metal to use for condenser tubes. It may be said, however, that Admiralty tubes are favored by a large majority of plant operators and are used even where the water is not of a corrosive nature. The results of a test to determine friction and other losses in various parts of the circulating water system through one of the 55,000 sq. ft. condensers at Long Beach is shown in Fig. 5. Under normal operation these condenser tubes become coated with a thin layer of marine growth which increases the friction loss in the tube about 0.7 ft. and reduces the heat transfer in the ratio of 350:300. This coating of slime will not wash off but can be blown out with air at about 100 lb. pressure. It is necessary to blow the tubes about every three or four months.

Speed and Weight, Issues in Oil Engine Design

Recent European Designs Show Trends Toward Increased Speeds and Decreased Weights in Oil Engine Practice. By F. Johnstone-Taylor

DURING the last few years several well known European builders of internal combustion engines have brought out lightweight oil engines. The type is of course a distinct one and aims at providing a motor with two, four or six cylinders, as the case may be, developing from 50 to 500 hp. at 800 r.p.m. These engines which function on the four stroke cycle are, as might be inferred, built upon gasoline engine lines with overhead valves, the principal feature in each case being a simple and efficient means of handling the fuel.

Fuel injection and ignition have naturally proved difficult to the designer of engines of this class, owing to the minute fuel charge required, the small fraction of time permissible for its injection and the desirability of operating with low compression pressure. One or two designs, however, could almost be considered to be of the high compression class and the fuel injection system is really that applied to the so-called "cold starting" engine in miniature. Others built on less costly lines make use of a vaporizing chamber or electrically heated plugs. While one design, the M. A. N., is definitely introduced as an automobile type engine and another, the Beardmore, is considered suitable for certain types of aircraft, there is no immediate prospect of these oil engines superseding gasoline engines for either road or air transport service, although the safety attached to them in the latter case is a strong incentive to their development for this purpose. Their main field at the moment appears to be for relatively powerful motors for the operation of certain classes of rail motor cars, contractors' machinery, agricultural machinery, etc., where a heavy, strong engine is required to operate

continuously at long periods of time. Under such circumstances, the relative cost of fuel between that of fuel oil and gasoline is found to be in favor of the oil engine. Then again, in the marine field for the propulsion of light high speed craft, this class of engine is very well suited since it has all the advantages of the gasoline type with the added ones of safety and cheapness in operating costs.

The Beardmore Engine

This is an interesting design which stands out in a class by itself on account of its extreme lightness of construction. By the use of steel, the builders have reduced the weight per horsepower to as low as ten pounds in the larger units which have six 12 in. dia. cylinders and a speed of 750 r.p.m. Smaller engines with a bore of 8½ in. have an output of 50 hp. per cylinder. A section of the engine is shown in Fig. 1 from which it will be seen that the main crankcase casting, which is of steel, is in the form of a monoblock bored to receive steel cylinder liners and so to form the necessary water jacket. This main casting also carries the main bearings and has substantial base supports cast integral with it. The cylinder heads are of an aluminum alloy with alloy steel valve seats and phosphor bronze guides cast into them, while the pistons are aluminum alloy forgings machined all over. They have six cast iron piston rings and a scraper ring. The fuel injection valve is located in the center of the head and is of the type generally used on airless injection oil engines. The disposition of the valves will be noted. They are operated by means of rockers enclosed in the aluminum cover. The cam shaft as shown is mounted independently in the main casting and is driven by a series of gears housed in an independent steel casting at the end of the engine, to which also is attached a complete assembly of fuel, oil and water pumps together with a governor.

The M. A. N. Engine

While the designers of the Beardmore engine have obviously worked along airplane engine lines with the object of producing an extremely light engine of very high class, the M. A. N. engine is actually classified as an automobile engine and is being built essentially for heavy road vehicles and high speed light weight craft. It is rated up to 75 hp. in the 6-cylinder type running at 1250 r.p.m. The cylinder construction is shown in Fig. 2 from which it will be noted that with the injection nozzles, of which there are two to each cylinder, located at the side, the maximum possible valve area is available in the cylinder head. Here again there is no vaporizing system, the engine being of the straight solid injection class with an open nozzle type of spray valve which is devoid of moving parts. The fuel is supplied by independent variable stroke fuel pumps. The cylinder block has a plain exterior, the valves, push rods and overhead rockers being protected by covers.

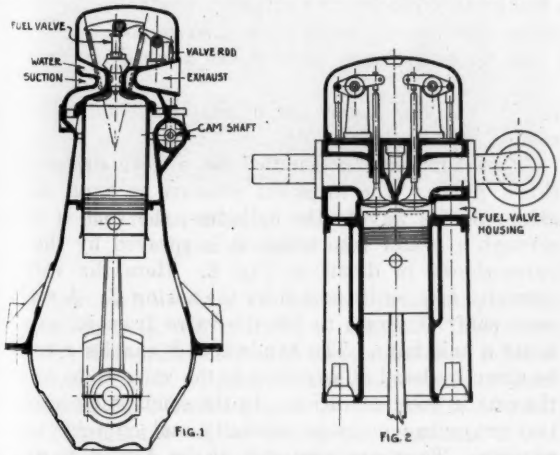


FIG. 1. THE BEARDMORE ENGINE, SHOWING MONOBLOCK FORM OF CRANKCASE

FIG. 2. SHOWING CYLINDER CONSTRUCTION OF THE M. A. N. ENGINE AND METHOD OF OBTAINING LARGE VALVE AREA

Another German Design: the Benz

The firm of Benz, associated with that of Mercedes, will be remembered as a successful builder of Zeppelin engines during the war. Figure 3 gives a view of one of these engines which are rated at 25 hp. per cylinder, having cylinders of 5.3 by 7¾ in., and operating at a speed of 800 r.p.m. An aluminum casing, forming the top half of the crank chamber, has cast iron cylinder liners pressed into it while the heads are separate as shown in detail in Fig. 4. The ignition chamber has the form of a spray bush at its lower end. Here are several small holes through which air on the compression stroke gains access to the combustion chamber. Here also the oil spray from the atomizer meeting with highly heated air becomes partially ignited. The pressure so created forces the explosive mixture into the cylinder where a relatively low pressure serves to ignite it. Each cylinder has its own independent oil pump of the cam operated variable stroke type which delivers the fuel at approximately 1000 lb. pressure to a spring loaded type of atomizer. The milled head shown thereon belongs to a needle valve which can be opened at any time to bypass the fuel back to the supply and so cut out any individual cylinder. The component shown behind the left-hand valve is an auxiliary igniter used to facilitate starting. It consists merely of an arrangement to hold

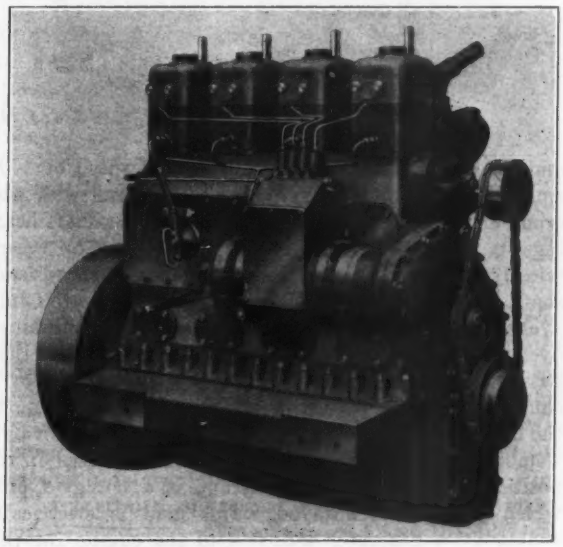


FIG. 3. THE BENZ ENGINE, SHOWING RIGIDITY OF CONSTRUCTION

a roll of absorbent paper soaked in nitrate of potash, which is ignited with a match. The overhead rockers are protected by detachable covers.

The Bagnulo Engine. Low Pressure Hot Grid Ignition

This Italian design, which is shown in Fig. 5, resembles in some respects, the general layout of the Beardmore engine, although the aim is to have a less costly construction. It is also a relatively small power engine being rated at 10 hp. per cylinder of 4-in. bore and 5½-in. stroke operating at a normal speed of 1400 r.p.m. The cylinder liner is cast integral with the crank chamber while the head, with the cam shaft bearings, is detachable. The fuel is handled by an eccentrically operated pump, driven from this overhead camshaft. The purpose of this pump is to deliver oil into a chamber in which a definite pressure is maintained by means of a spring loaded diaphragm. The oil then passes through the spray valves, being regulated by a cam operated distributor, the amount of fuel passing to the latter being under the control of an adjustable valve. Combined with the spray maker, which is housed in the position indicated on the diagram, is a hot grid onto which the fuel is sprayed. This grid is electrically heated by a generator attached to the engine for this purpose. As the temperature is controllable, the engine has an exceptionally wide range of speed.

This is an engine which has just been brought out by a British concern. It is intended essentially for marine work. With cylinders 5½ by 9 in. and rated at 120 hp., the arrangement with valves in head operated from two cam shafts in the crank chamber follows good marine practice. Cast iron cylinders are bolted to the crank chamber by flanges and there are four valves to each cylinder. These are housed in removable cages along vertical gas engine lines and in the center of the head is the fuel valve which directs the jet vertically downwards into the combustion chamber. The cylinder head is flat, but the piston has a small central projecting cone.

Fuel admission is handled by a gear driven four throw pump. The injection pressure is hand adjustable. On its way to the cylinders, the fuel is forced through a heater into which it is sprayed by the fuel valve shown in detail in Fig. 6. Here the valve is normally held on its seat B by the spring C. A rocking cross shaft D serves to lift the valve from its seat, E, being a ball joint. The handwheel F enables a turn to be given by hand at any time to the valve so as to keep the seat in good condition. In the combustion head are two projecting plugs horizontally and opposite to one another. They are arranged to be heated to incandescence, after which the engine can be started on paraffin. The engine is, however, designed to run on oil having a sp.gr. of about 0.895. Although it is rated at 120 b.hp., it weighs only 1½ t.

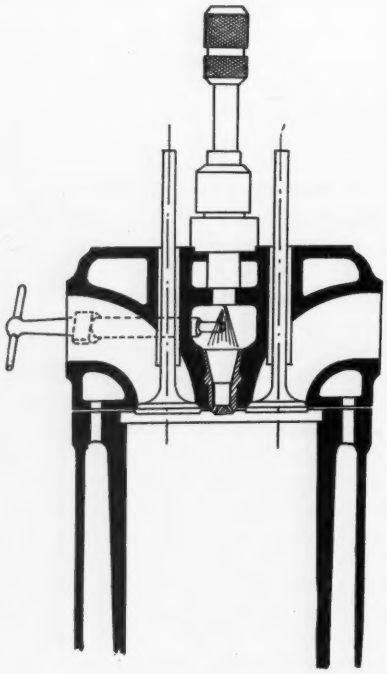


Fig. 4

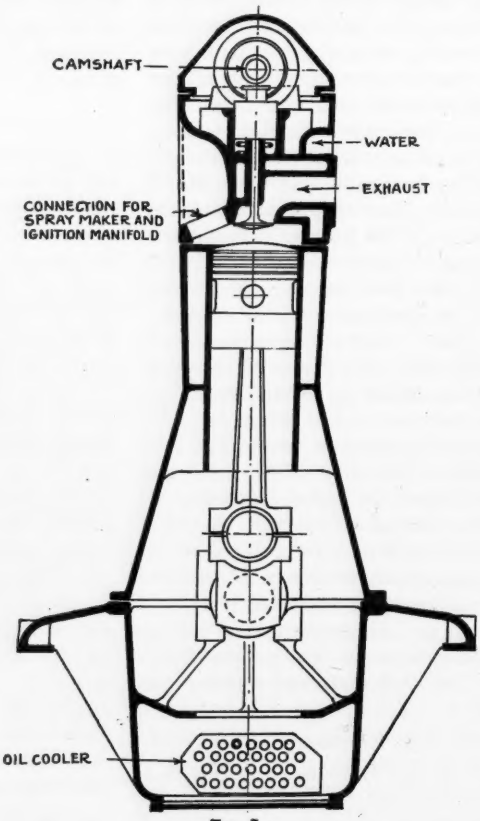


Fig. 5

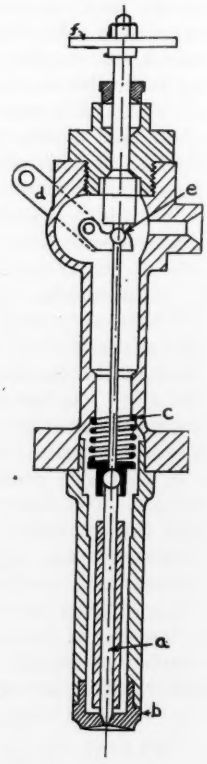
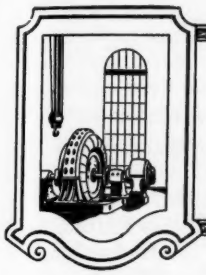


Fig. 6.

FIG. 4. CROSS-SECTION OF BENZ ENGINE SHOWING CYLINDER-HEAD AND COMBUSTION CHAMBER AND SMALL HOLES THROUGH WHICH AIR IS FORCED INTO COMBUSTION CHAMBER DURING COMPRESSION STROKE. FIG. 5. THE BAGNULO ENGINE SHOWING CYLINDER LINER CAST INTEGRAL WITH CRANKCASE AND REMOVABLE HEAD. FIG. 6. FUEL VALVE OF MUMFORD ENGINE



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Service Operation of Inertaire Transformers

A Discussion of the Operation of Inertaire Equipment with Reports on the Operation of Actual Installations. By L. H. Hill*

INERTAIRE EQUIPMENT is used with power transformers to prevent deterioration of the insulating oil and incidentally provides protection against the possibility of fires and explosions within the transformer case.

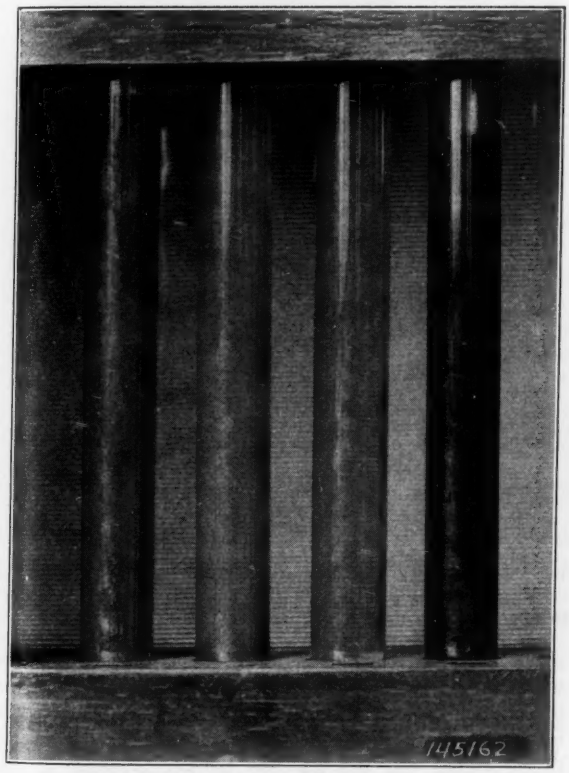


FIG. 1. TEST TUBES SHOWING EFFECT OF OXIDATION ON TRANSFORMER OIL

Oxygen and moisture are the two principal enemies of transformer oil met in service. Extensive laboratory tests have demonstrated that if these agents are isolated from insulating oil, no deterioration takes place. Figure 1 illustrates in a striking manner the results of such tests. The test tube at the left contains standard transformer oil as it is received from the refinery, while the other three tubes show the result of an accelerated life test obtained by heating at 200 deg. C. for a period of about one week. The second and third tubes were in contact with inert gases during this time, while the fourth was open to air. The tubes in which the oil was protected by inert gas plainly show the entire absence of oxidation, while in contrast, the darkened color of the oil in the fourth tube clearly shows the effects of oxidation.

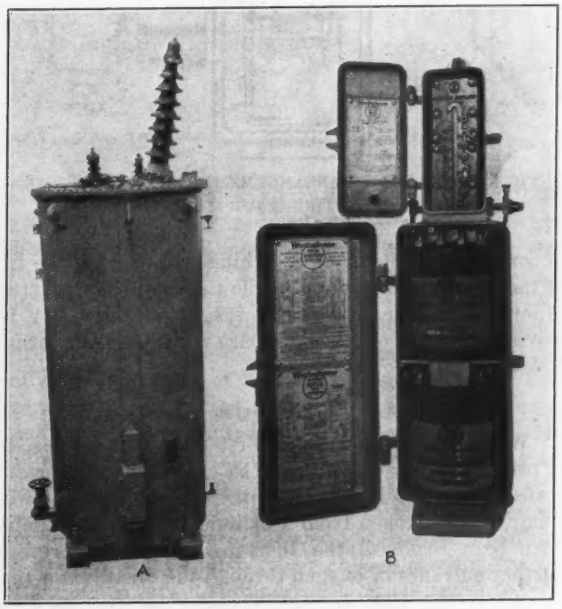


FIG. 2. DETAILS AND APPLICATION OF INERTAIRE EQUIPMENT

A. Transformer with Inertaire equipment mounted on side. B. Detailed view of Inertaire equipment. Inertaire compound jars below. Breathing regulator at the top.

Inertaire equipment maintains a protective layer of nitrogen above the oil in the transformer case. In addition to protecting the oil from deteriorating, the inert gas space between oil and cover serves a valuable function in providing a cushion to protect the case against dangerous pressures which have been known to arise due to internal disturbances.

The Inertaire equipment, which creates and maintains the inert protective gas space above the oil level, operates through the natural breathing of the transformer. It is contained in a cast iron cabinet, which is

*Transformer Engineering Dept., Westinghouse Electric and Manufacturing Co.

bolted on the side of the transformer tank, as shown in Fig. 2A. The appearance of the same equipment with the doors open is shown in Fig. 2B. The large lower compartment contains two jars of Inertaire compound which are factory-filled glass containers shipped ready for use by simply removing the shipping caps and connecting to the unions in the cabinet. The upper compartment contains the breathing regulator which is used

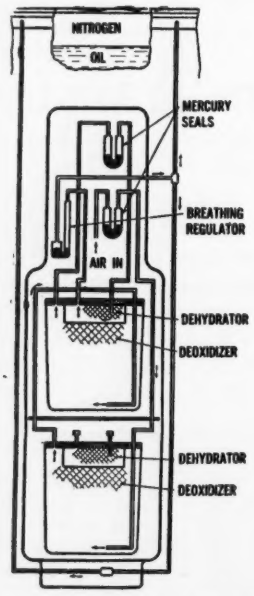


FIG. 3. SCHEMATIC ARRANGEMENT OF PARTS OF THE INERTAIRE EQUIPMENT

to control the amount of breathing and prolong the life of the Inertaire compound, while the small compartment below the main case contains the fittings used for removing the air from the gas space when the transformer is first installed.

Operation of Inertaire Equipment

When the transformer is first placed in service, air is present above the oil in the case. With the Inertaire transformer this air initially present is blown out with compressed nitrogen from a cylinder. After the air has once been removed, the Inertaire equipment prevents further entrance of oxygen through the breathing action.

When the load on the transformer increases, its losses increase and the oil and gas in the space above the oil tend to expand due to the increase in temperature. The breathing regulator is a modified mercury U-tube which does not permit the escape of gas from the tank until the pressure in the gas space becomes approximately 5 lb. per sq. in. If the rise in temperature is such that this pressure is reached, the excess gas escapes through the breathing regulator and Inertaire compound containers.

When the transformer cools down, the reverse action takes place. If the oil and gas contract and cool to such a degree that a slight vacuum is obtained on the tank, the breathing regulator admits gas and makes up the deficiency as in ordinary breathing operations. In this case, however, the air from the atmosphere comes in through the deoxygenating and dehydrating materials in the glass jars and is there deprived of the undesirable constituents of ordinary atmospheric air, oxygen and moisture.

The First Inertaire Installation

The first installation of Inertaire transformers was made in June, 1924, and consisted of seven of the 8333-kv.a., 66,000/13,200-v., water-cooled transformers. The Inertaire equipment used with this installation used one large jar of compound instead of the two smaller jars shown in the later equipment, Fig. 2B. One of the principal advantages of using two small jars instead of one large one is that the time of making renewals is more flexible. With the two-jar arrangement, the material becomes used from the bottom of the bottom jar and upward. Used material is indicated by a change in color from cocoa color to blue. When the color change reaches approximately one-half way in the upper jar, this jar is removed and placed in the lower position in

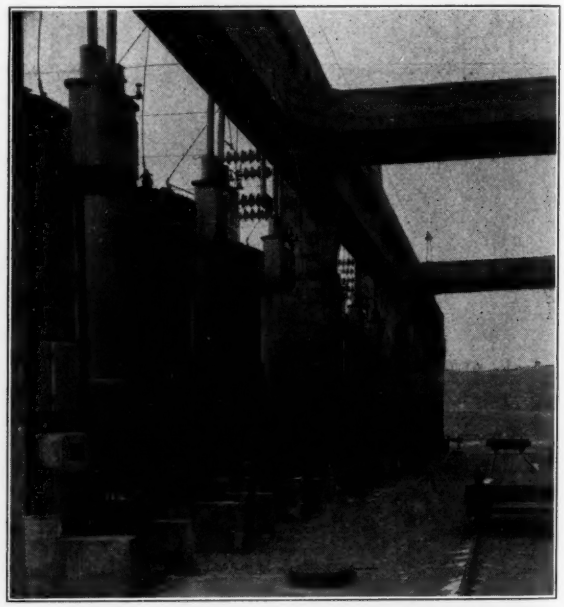


FIG. 4. PARTIAL VIEW OF A GROUP OF 13 INERTAIRE EQUIPPED TRANSFORMERS

place of the entirely used jar which is discarded. The wide margin in the upper jar permits changing all jars in an installation at once instead of one at a time as might be the case if only one jar were used and the transformers did not all use their compound at the same time.

There were a number of interesting things noted in connection with the installation of these first Inertaire transformers. The transformers had stood idle and sealed up with air in the space above the oil some two or three months before the Inertaire equipment had been added. Gas analyses taken at this time showed the oxygen content of the gas space to be about 17 per cent instead of 20.7 per cent which is the oxygen percentage of the atmosphere. This reduction in oxygen content illustrates the slow oxidation which takes place even at atmospheric temperature when oil is in contact with air. In this case the oxygen supply was limited,

so the slow combination of oxygen from the air space with the oil caused a reduction in the per cent oxygen. Oxygen is also somewhat more soluble in oil than is nitrogen, which also makes for a reduction of oxygen content in the gas space.

This question of dissolved gases in the transformer oil appears in another connection. The oxygen was initially removed from the gas space by blowing in nitrogen from a cylinder. This reduced the oxygen to less than 1 per cent. After standing over night, the oxygen content came up to 3 or 4 per cent. After blowing down again to less than 1 per cent, the oxygen came up to about 2 per cent.

This rise in oxygen content is due to the air coming out of the oil. It is not generally appreciated that transformer oil, if left in contact with air at ordinary temperatures, will absorb as much as 15 per cent of its own volume of the air. With the oil in a transformer tank and with air above it, the oil absorbs the air until it becomes saturated. This air in solution is continually coming out of the oil and being replaced with air from above. When this air is swept out during the initial blowing out process, and is replaced with nitrogen, the air coming out of the oil naturally tends to increase the percentage of oxygen in the gas space. Even with two or three blowing-outs with nitrogen it is difficult to remove all of the oxygen in the oil and it is found that the oxygen content of the gas space will vary somewhat due to oxygen coming off the oil at different rates due to changing temperature conditions. It is fortunate, however, that all but a small proportion of the oxygen is readily removed with two or three blowing outs. After this has been done, the oil contains nitrogen in solution instead of air, and is ideally protected against further oxidation.

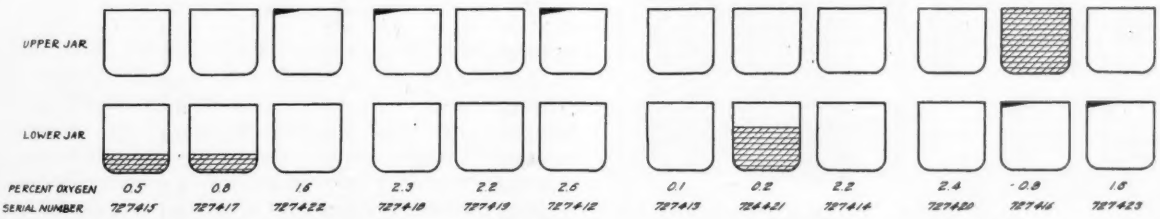


FIG. 5. GRAPHIC RECORD OF THE OPERATION OF THE INERTAIRE JARS ON 12 OF THE TRANSFORMERS SHOWN IN FIG. 4

Later Installations

During the two years following the initial installation, the use of Inertaire equipment has spread rapidly. At present over 300 power transformers provided with Inertaire equipment are in operation, representing a total installed capacity of over 3,000,000 kv.a.

Inertaire equipment of the same size is used with all sizes of power transformers. The amount of breathing and hence the amount of Inertaire compound used is largely a function of the size of transformer and the type of load cycle. Small transformers operate on more varied load cycles than large ones, so the difference in breathing is not as great as it might appear to be. Self-cooled transformers breathe more than water-cooled transformers largely on account of the great amount of oil in the radiators. Variable ambient temperature also contributes to the breathing and on this account outdoor transformers have been found to breathe more than those located indoors.

By permitting the gas to store up in the gas space, the breathing regulator tends to smooth out variable load curves and so reduces the breathing enormously. In the case of the 8333-kv.a. transformers referred to above, the effect of ambient temperature between night and day would cause a difference of 1½ to 2 lb. per sq. in. in the transformer gas space.

One of the important factors governing the amount of breathing with Inertaire transformers is the amount of leakage from the transformer case. The gas which leaks out must be replaced by breathing in more air, which naturally uses up more Inertaire compound.

In general, the life of one Inertaire compound jar is between six months and a year. There are many cases where the life of the jar will be more than a year and there are very few jars which do not last more than six months. Short life may generally be traced to an unusual amount of leakage in the transformer case.

Figure 4 illustrates an installation of 13 10,000-kv.a., 66,000-v., water-cooled transformers provided with Inertaire equipment. These transformers were installed during the Fall of 1925 and were provided with new improved Inertaire jars in February, 1926. They were operated without attention until August, 1926, when they were inspected. Figure 5 shows graphically the operation of the two Inertaire jars of each transformer. The used material, after six months of operation, is represented by the cross-sectioned area. The oxygen contents at the end of the six months are tabulated below the figure.

It is evident that in the case of this installation, the jars will last for years. In most cases, the breathing has been so slight that no color change is visible at the bottom of the jars. Normal discoloration proceeds from the bottom of the bottom jar toward the top of the top jar. The slight discoloration evidenced in the upper left-hand corner of some of the jars represents an unusual condition caused by a loose shipping cap or slight leak through the jar seal. This does not affect the operation of the equipment. The lower jars in three transformers show considerably more discoloration than the others. This illustrates the effect of leakage upon the amount of compound used. The low oxygen contents indicate that normal operation proceeds even with leaky tank structures.

In one case the upper jar is entirely discolored. This is due to the fact that this jar was accidentally broken. The crack in the jar permitted air from the atmosphere to enter the jar, causing the discoloration. The breaking of an Inertaire jar is an almost unheard of thing on account of the fact that only the best grade of heat

resisting glass of higher mechanical strength is used. It is interesting to note that even under this extremely unusual and abnormal condition the equipment continued to maintain low oxygen contents.

Seven per cent is the lower limit of explosibility, but it is recommended that oxygen contents be maintained below 3 per cent. It will be noted that in all cases the oxygen content is well below this value. Generally oxygen contents run 1 per cent or below, when the dissolved air has been completely removed from the oil initially.

Figure 6 shows actual service data taken on some 10,000-kv.a. water-cooled and 5000-kv.a. self-cooled transformers on another system. The shaded areas represent the used material in the jar at the dates indicated. The percentages tabulated denote the oxygen contents at the different times.

These records show that the oxygen content, while always low, fluctuates during normal operation. In general, the oxygen content tends to become lower as

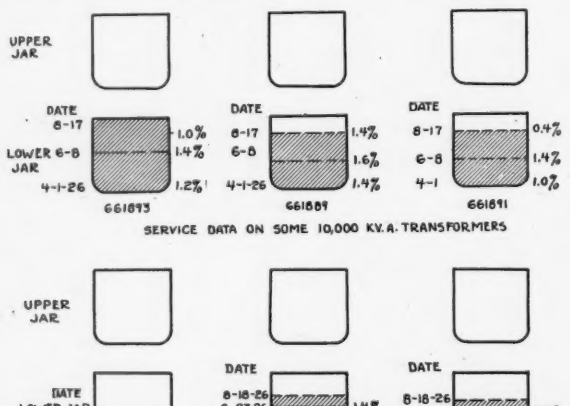


FIG. 6. ACTUAL SERVICE DATA ON SOME 10,000-KV.A., WATER-COOLED, AND 5000-KV.A., SELF-COOLED TRANSFORMERS

time goes on. This is due to the combination of the residual oxygen with the oil and dilution with nitrogen during the breathing process.

In the accompanying table is tabulated oxygen determinations taken over a six-months period on some 4000-kv.a., 66,000 to 120,000-v. transformers.

Some difficulty was experienced with the early installations of Inertaire equipment due to leakage of the transformer cases. This was due in part to the erectors' inexperience with gas tight construction and to certain characteristics of the early compound jars.

Since the early installations, the mechanical structure of the transformer cases has been improved, and erectors have become familiar with the requirements. With present equipment, leaks, unless unusually large, do not affect operation beyond an increase in the amount of the compound used.

The gas analyzer generally used with Inertaire equipment to determine the oxygen content, is a modification of the familiar Orsat apparatus used for flue gas analysis in the power plant, and enables the operator to measure the oxygen content very accurately.

Operating experience has shown that after the Inertaire equipment has once been installed and the oxygen removed from the oil, weekly readings for two or three weeks will show whether operation will be satisfactory or not. If these readings show oxygen contents below 2 or 3 per cent for three consecutive weekly readings, the operation will generally be entirely satisfactory.

Some installations have been left for as long as eight months without inspection and found to be low in oxygen content at the end of the period. As a rule, an oxygen analysis every month or two is advisable to make certain that perfect operation is being obtained. Increase in oxygen content will almost always indicate a leak of considerable magnitude.

Leaks may be located by blowing in nitrogen so as to build up a pressure of 2 or 3 lb. in the gas space. Large

RECORD OF OXYGEN PERCENTAGES ON A BANK OF 4000-KV.A. TRANSFORMERS

	Oxygen in Per Cent		
Date	A	B	C
3-11-26	2.5	0.8	0.0
3-18-26	1.5	0.2	0.0
4- 5-26	2.7	0.8	0.6
4-10-26	2.0	0.6	0.0
4-20-26	2.5	0.4	0.0
4-29-26	1.9	0.6	0.0
5-13-26	1.7	1.0	0.0
5-28-26	1.5	0.4	0.0
9-27-26	1.9	1.5	0.5

leaks may be located by sound, and smaller ones by painting the joints with soapy water.

Occasionally it may become necessary, due to some unusual condition, to filter the oil in an Inertaire transformer. There are some types of filter presses and centrifuges in which air is mixed with the oil during the dehydrating process. This air diffuses from the oil in the transformer case and increases the oxygen content in the gas space. This oxygen is removed by blowing out with nitrogen as in the case of the original installation. For this purpose, the special cylinders of nitrogen, furnished with Inertaire equipment, may be retained as long as desired without incurring the usual demurrage charges for gas cylinders.

Modern transformers are generally provided with tap changers so that it is seldom necessary to open the transformer manholes for any purpose. In case this is necessary, however, the diffusion between the atmosphere and gas space is very rapid so that it is possible to enter the case almost immediately. After closing the manhole it is only necessary to blow in one charge of nitrogen unless the transformer oil had been left exposed to air for several days. In the latter case oxygen would have been re-absorbed, making it necessary to displace the oxygen from the oil.

It has been demonstrated that Inertaire equipment maintains low oxygen contents above the oil in transformers in service so that the beneficial effects of inert gas on the oil indicated in Fig. 1 are being obtained. The efficacy of the dehydrating part of the Inertaire jar has been proven many times by use in very damp sections of the country. In one case with transformers of the type having an air space above the oil, moisture

conditions were so bad that it was necessary to filter the oil once a week. Inertaire equipment was applied to these units, and after ten months of operation it had not become necessary to filter the oil.

Three cases of trouble are known in transformers protected by Inertaire. In one case the transformer was struck by lightning, which destroyed one of the coils. In another case, the transformer failed due to a wrong internal connection. In the third case a high voltage bushing failed below the oil level. In each of these cases considerable energy was available at the fault and the circumstances could very well have resulted in some serious trouble such as has actually occurred under such conditions. Inertaire equipment with its protective gas cushion and relief diaphragm, prevented any external disturbance or damage to the transformer case.

Electric Control for Fuel Oil Pumps

By E. G. Peterson*

IN THE PROCESS of converting the coal burning vessels, the U. S. S. Florida, Utah, Arkansas, Wyoming, Texas and New York, to the use of fuel oil, several difficult but interesting problems came up. Not the least of these was the control of the electrically driven fuel oil pumps. These pumps are of the positive displacement type and were required to meet rigid government inspection. Their capacity as ten gal. per min. of fuel oil having a viscosity of 11,250 sec. Saybolt Fural, 300 deg. Engler, against a discharge head of 300 lb. gage pressure positive suction head.

These pumps are driven by compound wound direct current motors rated at 5 hp., 120 v., 800—1600 r.p.m. The motors are of splash-proof construction, designed for minimum weight and space.

In order to obtain satisfactory operation it is desirable to maintain a constant predetermined discharge pressure at the pump regardless of variations in the steam line pressure. It is desirable, moreover, to be able to vary the quantity of fuel oil pumped at this constant pressure depending upon the amount of fuel necessary to maintain a constant boiler pressure under all conditions of load. For this purpose, a special oil pressure regulator was designed, which embodies a horizontal cylinder, the operating piston of which moved forward and backward under variations of the oil pressure. This piston was provided with a rack and connected mechanically to a field rheostat so that changes in position of the oil pressure regulator piston would cause corresponding changes in the motor field rheostats which were used to speed up the motor or slow down the motor so as to maintain the desired constant pressure. A field rheostat designed for this purpose is illustrated in Fig. 1. It is totally enclosed in a non-watertight ventilated wall type case. A circular hole in the side is for the rack rod drive from the oil pressure regulator piston. A spur gear is mounted on the rheostat shaft behind the panel and is arranged to rotate the rheostat lever, depending upon the horizontal movement of the pressure regulator piston. A handwheel is also provided for emergency manual operation.

*Electrical Engineer, The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Automatic starting and stopping of the motor is obtained from a watertight enclosed automatic self-starter, from a remote point by a waterproof "on" and "off" pushbutton station. This self-starter includes main line, double pole, single throw knife switch; single pole, hand reset main line overload relay; double pole main line magnetic contactor; one single pole series lockout type accelerating contactor; one vibrating field relay to protect the motor against too rapid weakening or strengthening of the shunt field; two pilot fuses, and a Navy test link. Figure 2 shows an open view of this self-starter.

The hand reset overload relay will shut down the motor in event of a continued overload that would seriously damage the motor. Low voltage or voltage failure will drop out the automatic starter but the equipment will restart again automatically upon return of normal voltage to the supply system.

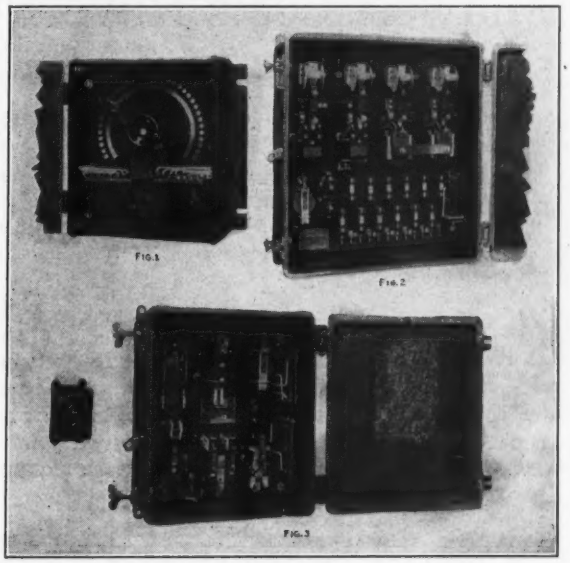


FIG. 1. NON-WATERTIGHT PANEL TYPE FIELD REGULATOR FOR PUMPS ON SHIPBOARD

FIG. 2. WATERTIGHT LOCKOUT TYPE SELF STARTER. PUSH BUTTON CONTROL SWITCH SHOWN AT LEFT

FIG. 3. WATERTIGHT, MAGNETIC TYPE TRANSFER PANEL

In line with established Navy practice for operation of auxiliaries essential to the operation of the vessel, an emergency power supply from the storage battery bus is provided. The normal power supply and the emergency power supply are connected to a watertight magnetic transfer panel as illustrated in Fig. 3. This automatic transfer panel is designed with a capacity for handling four motors on several of the vessels and six motors on the larger vessels which have six fuel oil pumps. This transfer panel consists of two normally open magnetic contactors and two spring closed magnetic contactors, a voltage relay, a control relay, a pair of line fuses for each motor on the system. If the voltage on the generator supply line is 115 v. or higher the voltage relay will close, which brings in the normally open double pole contactors known as the "generator" switches. This connects the load to the generator supply line which is the normal method of operation. In

case of an emergency which would cause the generator supply voltage to drop to approximately 110 v., the voltage relay will open and cause the generator contactors to drop out and the normally closed battery switches to close. This connects the motors to the battery bus without interruption of operation. The transfer back to the generator supply bus will be automatic when the voltage returns to 115 v. on the generator bus. The battery switches are held normally closed by the action of a powerful spring so as to keep the load connected to the battery supply line at all times that the voltage on the generator supply line is not up to normal. The control relay is used in connection with the voltage relay to insert a resistance in the voltage relay coil in order to make it more sensitive and provide for the automatic transfer over a very narrow range of voltages as indicated.

These controllers were required to meet a rigid Government inspection as to construction, water-proofness, heating, dielectric strength, and insulation, operation under Class "A" shock, and 30 deg. inclination in any direction. The operation of this control equipment is essential under any conditions of rolling of the ship or shock from gun fire and every precaution possible was included with this in mind. The magnetic contactors have all metal parts zinc plated, the panels are of asbestos lumber and resistor units are encased in a metal sheath. All the contactors are either provided with a tail weight or a spring to prevent their closing under 30 degree inclination. The successful solution of this control problem illustrates what can be accomplished by proper co-operation between the user, the machine manufacturer, the motor manufacturer and the control manufacturer.

Midwest Coals Have Diversified Characteristics

WHILE EACH COAL HAS ITS OWN PECULIARITIES, THEY CAN ALL BE BURNED IF PROPERLY HANDLED ON SUITABLE EQUIPMENT. BY E. L. McDONALD*

STEAM COALS available from the Midwest fields come from various sections of the states of Iowa, Missouri, Kansas, Arkansas, Oklahoma and Illinois. They vary in character from the very low grade Iowa coals to the semi-anthracite of Arkansas, and are mined by a variety of methods ranging from the strip pit to deep shaft.

Typical analyses are shown in the table and while they do not show the true burning characteristics of the coal, they do indicate the general nature and variations. The analyses are not extreme in either direction, but have been picked out to represent average good and average poor coal as received at the power plant and should not be confused with samples taken from the coal field, which always indicates a better quality.

TYPICAL ANALYSES OF COALS FROM VARIOUS DISTRICTS SHOW THE WIDE VARIATION THAT MAY BE EXPECTED

STATE	COUNTY	NO.	GRADE	ANALYSIS OF COAL AS RECEIVED, MOISTURE	ASH	VOL.	F.C.	B.T.U.	B.T.U. DRY
Illinois	Sangamon & Macoupin	1	Good	14.20	11.89	35.16	38.75	10,380	12,070
			Poor	13.34	13.80	31.00	41.86	9,915	11,440
Illinois	Franklin	2	Good	13.93	9.27	34.80	42.00	11,190	13,001
			Poor	12.94	11.62	33.00	42.44	10,827	12,425
Iowa	Boone	4	Good	12.30	18.60	37.20	31.90	9,773	11,144
			Poor	13.90	27.20	28.50	31.10	7,503	8,640
Iowa	Appanoose	5	Good	20.80	24.12	28.00	27.08	8,741	11,020
			Poor	17.38	31.96	25.00	25.71	7,408	8,596
Missouri	Randolph	6	Good	13.25	19.09	30.33	37.37	9,492	10,941
			Poor	13.45	23.45	28.00	35.10	8,767	10,117
Missouri	Bates	8	Good	13.88	18.46	30.66	37.00	9,702	11,266
			Poor	13.55	23.08	28.62	34.80	8,680	10,030
Arkansas	Sebastian & Johnson,	10	Good	3.50	11.57	14.93	70.00	12,850	13,316
			Poor	3.50	21.36	10.30	64.84	11,680	12,325
Kansas	Leavenworth	7	Good	10.69	24.36	27.60	37.33	9,465	10,620
			Poor	11.41	27.17	26.93	35.49	8,845	9,990
Kansas	Crawford & Cherokee	9	Good	6.80	13.86	27.57	51.67	12,187	13,080
			Poor	7.50	19.36	27.31	45.83	10,793	11,690
Oklahoma	Pittsburg	11	Good	6.76	6.78	15.25	71.17	12,817	13,737
			Poor	5.00	18.83	12.60	63.57	10,950	11,526

While the burning of coal in pulverized form is undoubtedly the ideal method from the standpoint of thermal efficiency, at present there is more reliable information available on the burning of these coals on forced draft stokers. The Northeast station of the Kansas City Power & Light Co. at Kansas City, Mo., has available to it, through competitive freight rates, and has burned coal from all these fields and the data given were obtained from forced draft chain grate stoker units similar to Fig. 1, installed in this station.

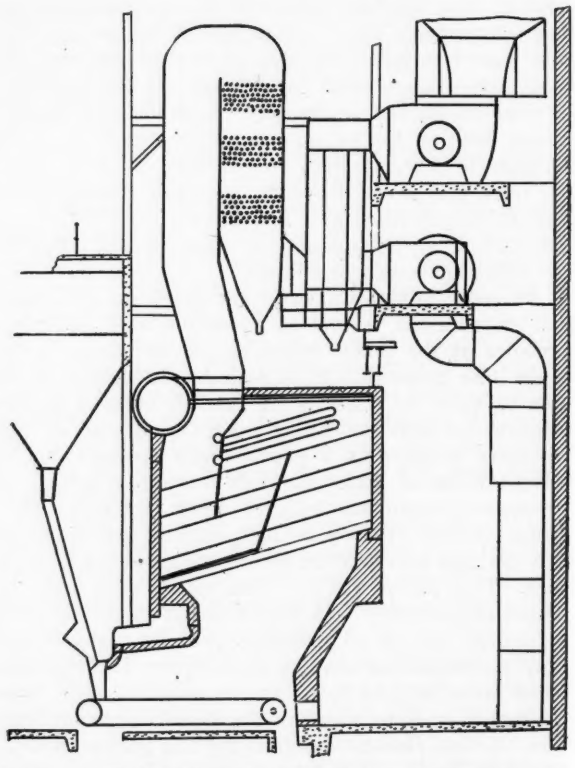


FIG. 1. CROSS SECTION OF A BOILER AND SETTING IN THE NORTHEAST STATION

Due chiefly to its ability to control the air supply to any portion of the fuel bed, the forced draft chain grate stoker is well adapted to the burning of midwest coals and the extent to which this control of air is desirable is best shown graphically. Four coals with different burning characteristics have been selected and Fig. 2

*Efficiency Engineer, Kansas City Power & Light Co., Kansas City, Mo. Abstract of paper presented before the A. S. M. E., Kansas City, Mo., April 4-6, 1927.

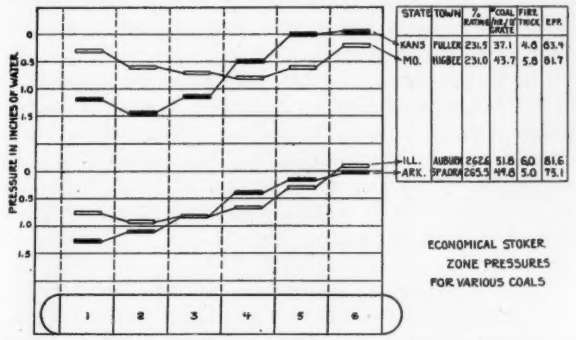
shows the different zone pressures desirable when burning various coals under the same boiler rating.

Difference in air pressures required in the burning of these coals is caused principally by rapidity of ignition, coal sizing, per cent and fusion temperature of the ash in each coal. Coals slow to ignite demand less air in the front stoker zone. The theoretical temperature required for the ignition of fixed carbon in bituminous coal is about 770 deg. F. Ordinarily 1800 to 2000 deg. F. actually exists at the front of the arch.

Character of Screenings from Different Fields Varies

Coals fine in size require thinner fuel beds and usually more pressure to break through the fuel bed. Arkansas anthracite is in this class; being fragile, it cracks easily and 1¼-in. screenings will contain about 75 per cent through ¼-in. screen, whereas 1¼-in. Illinois screenings will contain only about 30 per cent through ¼-in. screen.

Coals with a low fusing temperature ash naturally require more air pressure to overcome this resistance. The fusion temperature of some of the low grade midwest coals will run as low as 1800 deg. F., while others



STATE	TOWN	% RATING	COAL/HR/SQ FT GRATE	FIRE THICK	EFF.
KANS	FULLER	231.5	37.1	4.6	63.9
MO.	NIGBEE	231.0	43.7	5.8	61.7
ILL.	AUBURN	262.6	51.8	6.0	81.6
ARK.	SPADRA	265.5	49.8	5.0	75.1

FIG. 2. FORCED DRAFT PRESSURE IN VARIOUS SECTIONS OF THE STOKER MUST BE VARIED WITH THE TYPE OF COAL BEING BURNED

will run between 2000 and 2180 deg. F. Ash fusing at a low temperature and during the early stage of the combustion will completely imbed carbon particles, and prevent air from coming in contact with them to complete their combustion. While this occurs to some extent in the burning of any kind of coal, it is naturally more pronounced in most of the midwest coals with their high percentage of low fusion ash.

Low fusing ash resulting in high ash pit losses, together with high moisture and hydrogen content, result in unavoidable stack losses and explain why efficiencies cannot be obtained with midwest coal equal to those obtained with some eastern coals. Moisture plays a very important part in the burning of midwest coals on chain grate stokers. For example, the average moisture content of Missouri coal is 12 to 14 per cent, but coal is often received containing over 20 per cent. With this high moisture, ignition and proper combustion is difficult. On the other hand, coal is received from the other fields, particularly Arkansas, with a moisture content too low for good firing conditions, and moisture must be added to obtain a uniform fuel bed, or prevent holes from blowing through and carrying the particles up to the boiler and out of the stack.

Coals Burn with a Characteristic Flame

Each of these midwest coals has its own peculiarities in burning, most Missouri coals burning with a long, heavy flame, with furnace temperature of about 2700 deg. F. at normal rating. Kansas coals burn with a somewhat shorter and cleaner flame and develop about 2850 deg. F. furnace temperature at normal rating. Many of the Kansas coals are of a coking nature.

Oklahoma coals can develop high boiler temperatures, and most of them are highly coking. Arkansas anthracite burns with a short, transparent flame, practically the entire fuel bed being visible. Due to its fineness and light structure, millions of small incandescent carbon and ash particles are lifted from the fuel bed, some falling back on the rear of the stoker like snow, and some traveling through the boiler passes in

FIG. 3. PHOTOGRAPH TAKEN FROM THE REAR OF THE STOKER LOOKING UP AT THE BADLY SLAGGED LOWER ROWS OF TUBES

the form of red hot sparks. This coal cannot be successfully burned in a natural draft chain grate stoker.

Because of the high ash, sulphur and iron content of most of these coals, slagging problems are more acute than with many eastern coals, and ample cleaning facilities must be provided, not only in the form of soot blowers, but rodding doors must be provided to permit knocking out the heavy slag deposits in the front pass of the boiler. The extent to which boilers will slag up with some midwest coals is shown in Fig. 3. This was taken from the rear of the stoker, looking up into the first pass of the boiler, and shows conditions after nine days' operation at 200 per cent rating with Kansas coal. Gas passages are practically plugged solid, the size of the original opening being shown in the center where the slag has been knocked off. Rodding doors have been used for several years for removing this slag, but even with this provision, boilers must come down every 25 or 30 days for a general cleaning.

Bituminous coal is commonly referred to as free-burning coal. As a whole this is correct, but with some of the midwest coals running up to 35 per cent ash impurities, the expression "free-burning" is a misnomer. In fact, on certain equipment it is often difficult to maintain their ignition, although this has been

improved greatly in the past few years by the application of preheated air.

Air Preheaters Allow Higher Boiler Ratings

At Northwest station, an air preheater increases the temperature from 70 to about 200 deg. F. At this temperature there are no detrimental effects on the stoker or furnace setting, although in heating air to 500 deg. F. on some more recent installations trouble has been experienced.

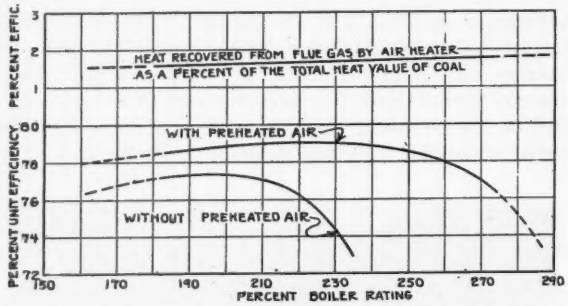

PERCENT EFFIC.
HEAT RECOVERED FROM FLUE GAS BY AIR HEATER AS A PERCENT OF THE TOTAL HEAT VALUE OF COAL
WITH PREHEATED AIR
WITHOUT PREHEATED AIR
PERCENT UNIT EFFICIENCY
PERCENT BOILER RATING

FIG. 4. PREHEATED AIR MATERIALLY INCREASES THE BOILER EFFICIENCY AND THE BOILER RATING WHICH CAN BE MAINTAINED

Preheating permits more rapid combustion, less excess air and higher efficiency, and the effect on a certain midwest coal is shown by the curves in Fig. 4. These show the efficiencies and ratings derived from the same kind of coal when burned with and without preheated air. It is, of course, an extreme case, and all coals do not show such pronounced gain. On the unit shown, the average gain at normal rating is about 3 per cent. The gain due to the heat units absorbed from the flue

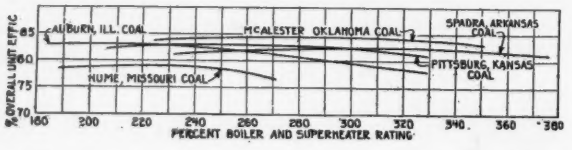


FIG. 5. TEST RESULTS WITH FIVE DIFFERENT COALS SHOW CONSIDERABLE VARIATION OF EFFICIENCY AND CAPACITY

gas is shown by the top line. From the difference in efficiencies, it is evident that the gain by preheating air for combustion, particularly at higher rating is considerably in excess of that accounted for in heat units absorbed from the flue gas.

Efficiencies and capacities obtained with the average midwest coals are shown in Fig. 5, taken from actual test results obtained with five representative coals from five states. These tests were conducted on the boiler unit equipped with an air preheater and the unit efficiencies when burning all of the coals, except Missouri, average about 82.5 per cent, boiler ratings running up to 380 per cent. Because of excessive slagging and fluxing of the ash and fire brick at high temperatures, the units were normally operated at about 240 per cent of the boiler rating.

In summing up the burning of midwest coals, it may be said that while each coal has its own peculiarities and must be burned accordingly to obtain efficient results, they can all be burned if properly handled on the proper equipment.

State Control of Waterpower

REPORTING ON the development of waterpower resources in Tennessee, the joint committee of the legislature has favored immediate exercise of state jurisdiction to the extent necessary to conserve public interest. The report states that these resources belong to the whole people although riparian rights necessary to development may be private property, hence the state has power to prescribe and enforce terms under which sites may be developed and utilized.

United States governmental authority extends, says the report, over state waters only to the extent of maintaining capacity in the channels of navigable rivers. Control of non-navigable waters rests in the state but procedure should be by cooperation of state and nation.

The committee is against development or ownership by the state as capital required is too great and private development has proved more successful than public. It believes that the state can control the large corporations needed for private development, retaining full power to regulate rates and service. In any case development must have the consent of riparian owners.

Approval is given of a conference of southeastern states to agree on a concerted policy on water power development as it is felt that lack of such policy has held back development.

It is recommended that legislation be enacted to assert jurisdiction first by requiring a state license to develop water powers, second by establishing a state commission for granting such licenses and specifying conditions of development, third that this commission receive reports as to progress and cost of construction, fourth that it cooperate with national agencies where joint jurisdiction is involved.

Cost of administration is to be met by annual license rees to be paid by licensees or by a special tax. Whether other taxes be levied is left to taxing authorities since such taxes would be charged in expense of operation and added to rates hence passed on to the consumer. Attention is called to the fact that extra tax on hydraulic power puts it at a disadvantage as compared to steam power, hence may retard development of water powers.

Licensing for not over 50 yr. is advised with property subject to recapture by the state at expiration, compensation being made to owners, for value of the plant but not for good will or capitalized value of the license. Spite of its disapproval of state ownership, the committee recommends that if there is contest for a license between a municipality and private interests, the municipality be given preference if its plans are equally well adapted to utilize the water power resources.

ACCORDING TO THE REPORT of the Geological Survey, Department of the Interior, issued April 2 and covering the production of electric power by public utility power plants for December, 1926 and January and February, 1927, the total production in February was 6,085,950,000 kw-hr., an increase of 9 per cent over February, 1926. Of this amount 3,881,793,000 kw-hr. were produced by the use of fuel and 2,204,157,000 by the use of water power.

Lincoln Oil Refinery Has Model Power Plant

Overhead Trestle, Air Preheaters, Evaporators and Combined Bleeder and Mixed Flow Turbines Used in This Plant Which Is Designed Like a Small Central Station

POWER AND STEAM demands in the modern oil refinery are such that it is extremely difficult to lay out a proper heat balance. At the plant of the Lincoln Oil Refining Co. at Robinson, Ill., the problem has been taken care of satisfactorily by the use of a combined bleeder and mixed flow type turbine. Steam is received at the throttle at 250 lb. gage, 600 deg. F. and after passing through the impulse blades of the turbine, is bled out at 125 lb. for use in the refinery. Condensate from the entire plant is drained back to a large tank in the power house and non-condensed steam at about 1 lb. pressure is returned through the low pressure stages of the turbine to a surface condenser.

If the electrical load on the turbine is not sufficient to supply all the 125-lb. steam required, the deficiency

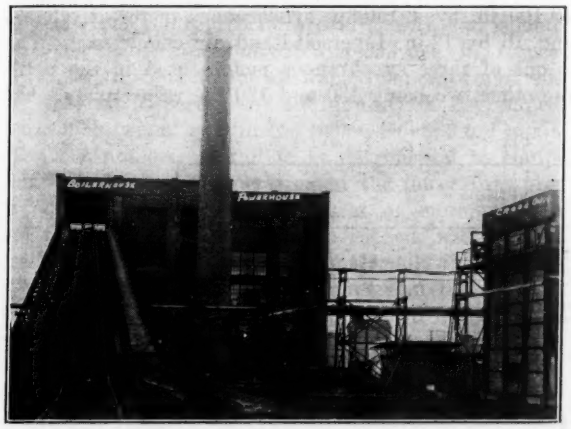


FIG. 1. COAL CARS ARE PULLED UP THE INCLINE AND DUMPED DIRECTLY INTO THE BUNKER

is made up from the 250-lb. line through an automatic reducing valve. The 125-lb. steam is usually superheated from about 150 deg. when all the steam is bled from the turbine to about 230 deg. when it is all supplied from the reducing valve.

In addition to the use of these turbines, the method of handling the coal and supplying preheated air for the stokers are of particular interest. Coal is received in hopper bottom cars. By means of an American cable way, driven by a 50-hp. General Electric motor, these cars are drawn up the incline trestle shown in Fig. 1 to be emptied directly into bunkers designed to hold four carloads. Three 526-b.hp. Henry Vogt Machine Co. bent tube boilers, fired by steam-driven forced draft, 9 by 13-ft. Combustion Engineering Corp. Coxe chain grate stokers, supply steam.

Breeching Used as Air Preheater

Air for combustion is drawn in by the forced draft fan around the Littleford Bros. steel boiler breeching, where the temperature is increased about 30 deg. before passing through the air preheater. The induced draft fans are on the boiler room floor directly behind the boiler. The air preheaters are above and the gases of combustion pass out of the boiler down through the preheater to the induced draft fan and are discharged to the breeching located below the boiler room floor. Air reaches the stoker at from 275 to 330 deg. F.

Furnaces are equipped with M. H. Detrick Co. arches with side walls protected by fin tubes. Mercon regulators maintain a pressure differential of about 40

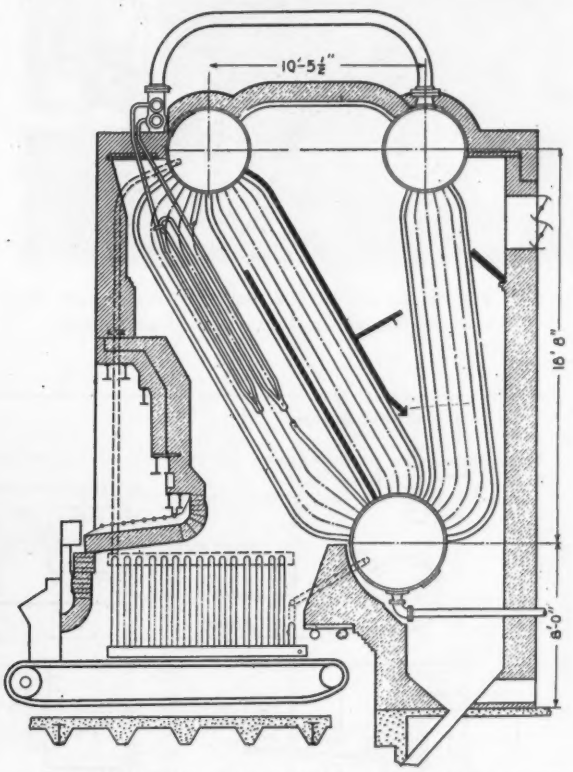


FIG. 2. WATER COOLED FURNACE WALLS ARE USED TO GIVE PROTECTION FROM THE HIGH TEMPERATURES

lb. between the feed water line and the boiler pressure and boiler water levels are maintained by Stets regulators. Power Piping Co. supplied the piping.

Feed water is supplied from one of two Goulds centrifugal boiler feed pumps, one driven by a 100-hp. Westinghouse motor, the other by an 87-hp. Westinghouse steam turbine. Makeup is taken care of by a 7200-lb. per hr. Griscom-Russell Co. single effect evaporator which is normally operated with 125 lb. steam although 250 lb. steam can be used if necessary.

Service water is supplied by two 7½ by 5 by 6 in. Worthington duplex steam pumps, while a third of the same type and size is used to maintain a constant level in the feed tank, in case the makeup necessary exceeds the capacity of the evaporator. Water for this purpose is taken from a water treating system in another part of the yard.

All fans were supplied by the Clarage Fan Co. and are driven by Westinghouse motors. Forced draft fans are driven at constant speed by 40-hp. motors running

at 1800 r.p.m. The induced draft fans have variable speed 50-hp. motors with a maximum speed of 690 r.p.m. All motor driven auxiliaries are 440-v. while the steam auxiliaries operate on 125 lb. steam. Apex CO_2 indicating and recording CO_2 meters, Bailey boiler meters and Diamond soot blowers and Carrick combustion

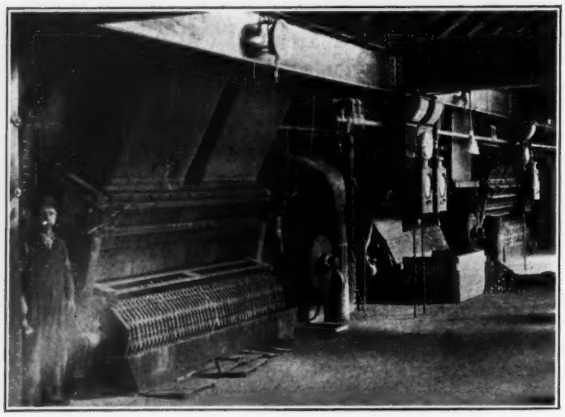


FIG. 3. FORCED DRAFT CHAIN GRATE STOKERS AND PREHEATED AIR ALLOW HIGH RATINGS TO BE CARRIED

control system are used. All instruments are read hourly, while the soot blowers and Beaumont ash hoppers are operated every 4 hr.

Each boiler is blown down every 4 hr. because the piping system for collecting condensate is not entirely completed. Treated water makeup runs about 5 gr. of hardness per gal. and is sufficient to raise the hardness in the feed tank to about 1.9 gr. per gal.

Electric current is generated at 440 v., 3 phase, 60 cycle and the two Westinghouse turbo-generators are rated at 1250 kv.a., 80 per cent power factor. Under normal operation, the throttle to the turbine can be closed and steam supplied to the 125 lb. system through the reducing valve. This steam returned to the turbine to the low pressure stages of the turbine is sufficient to carry 350 to 375 kw. load. Each turbine has a Westinghouse 2500-sq. ft. surface condenser equipped with a Westinghouse 2-stage air ejector, with inter and after cooler.

Ejector coolers and turbine oil coolers are supplied with raw water from the service pump system. Condensate pumps and circulating water pumps are on the same shaft driven by a single 100-hp. motor. Circulating water is cooled in a spray pond.

Synchronous Motors Keep Power Factor Up

Compressed air for the entire refinery is supplied at 100 lb. by a 150-hp. synchronous motor-driven 9¼ and 16 by 12-in. Ingersoll-Rand air compressor. This is one of three synchronous motors used in the plant, the other two being 130 and 120 hp. respectively. The three combined are sufficient to hold the system load factor up to about 97 per cent.

The plant was designed by R. H. Nicholson and supplies all the power and steam for the refinery. H. L. Deming is manager of the refinery and G. W. Uzell is operating engineer of the power house.

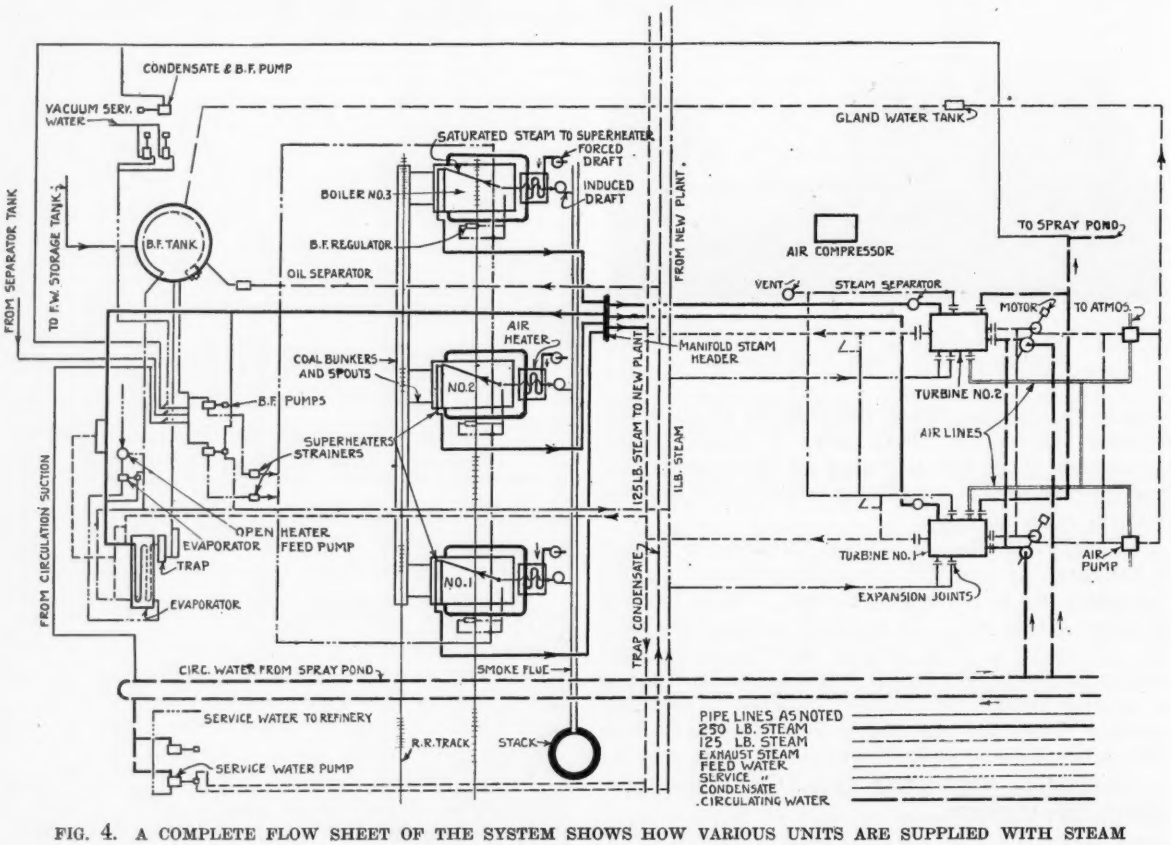


FIG. 4. A COMPLETE FLOW SHEET OF THE SYSTEM SHOWS HOW VARIOUS UNITS ARE SUPPLIED WITH STEAM

Cast-Iron Fittings for Superheated Steam

SOME OPERATING engineers still regard superheated steam as not worth consideration for their existing plants. They are fearful that the cast-iron fittings and valves in use will not stand up under the higher temperatures; also that lubricating oil will break down, but such is not the case.

Average existing industrial power plants where the steam lines have cast-iron fittings and valves are operating at from 100 to 125 lb. pressure, with corresponding steam temperatures of 338 and 353 deg. F., respectively. With a maximum allowable temperature of 450 deg., this would permit the addition of 100 deg. superheat, which, when used in the prime movers and auxiliaries, has not been found to be detrimental to equipment. In fact, when operating at the lower pressures the addition of 100 deg. superheat or more, until a total temperature of 450 deg. is reached, will effect a considerable saving. It will also materially increase the efficiency of the plant. Some conversion installations have used temperatures to 500 deg. without detriment to cast-iron fittings in the steam lines or the engine equipment and over 50,000 locomotives in this country are operated with temperatures upward of 700 deg. F. and pressures of 250 lb., all with cast-iron fittings to the superheaters.

Of course, when superheated steam is supplied to reciprocating engine equipment, the best grade of superheated steam valve oil should be used for valves and cylinder lubrication.

A large number of plants have increased their operating capacity by resorting to superheat, no changes in the plant being found necessary, aside from installing the superheaters in their boilers. E. C. GRIEF

Burning Out of Superheater Tubes Avoided

LAST SUMMER, during a period of heavy production in our mill, we were forced to run our boilers at very high ratings, and with fairly high concentration of solids and high alkalinity in our boiler water. We could not spare the boilers to empty and clean them on our regular schedule, so we had to carry them on the line longer than we should have.

It was not long before we began to notice that our safety valves began to pop more often than usual, even though our master steam gages, on the steam header, were not up to the popping pressure. The safety valves were set to pop at 200 lb., but after a time some of the boilers popped when the master gage registered only 175 lb.

Investigation showed that there were pressure drops, across some of the superheaters, as high as 25 lb. This, of course, was excessive. Those boilers that had been run at the highest ratings and were cleaned the least showed the greatest pressure drop. These boilers were popping about half the time, as we had to maintain 175 lb. steam line pressure.

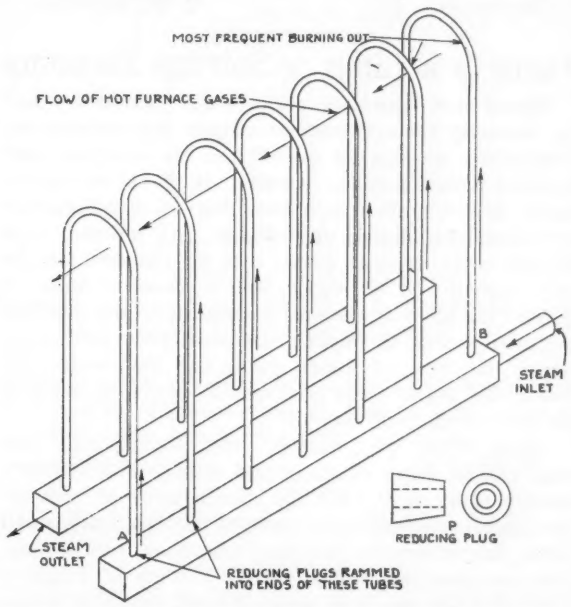


DIAGRAM ASSEMBLY OF SUPERHEATER TUBES SHOWING WHERE PLUGS, WHICH WERE MADE IN FORM SHOWN AT P, WERE FASTENED. BEFORE PLUGS WERE INSERTED, TUBES AT END A RECEIVED MOST OF THE STEAM; TUBES AT END B BURNED OUT BECAUSE OF LACK OF STEAM

Pulling out some of the tubes of the defective superheaters, we discovered them coated with considerable scale, some of them being almost filled between the cores and the tubes. While we realized that the boilers were foaming, we needed the boilers so badly that we hoped we might keep operating until the load was relieved by other means.

Something had to be done to get the steam into the lines that was going to the atmosphere via the safety valves, so we removed the cores to relieve the restrictions and give us more steam. We knew that the cores were supposed to be in, but we were desperate.

After removing the cores from the superheater tubes, we again started the boiler. About a week later a tube burned out. The adjacent tubes showed a little heating. We replaced the tube; soon another tube in the same location burned out.

After putting in a new tube, a third tube at this point burned out. We finally concluded that the area of the open coreless tubes was greatly in excess of that necessary to carry off the steam and that, by inertia, the steam was going past the near tubes and crowding the tubes at the discharge end of the manifolds. The by-passed tubes got so little of the steam that the heat could not be carried away, and they burned out. We were as badly off as before.

We then inserted plugs, as shown at P in the illustration, in the tubes, containing a hole of reduced diameter, thus restricting the area of the tubes and giving a more uniform distribution of the steam. At the same time some changes were made in the plant that relieved the steam requirements, giving us opportunity to reduce our rating, take care of our water and spare the boilers for cleaning and repairing. It was our intention to replace the cores in the tubes.

Dayton, O. C. W. Stevens.

There Is a Limit to Salvage Economy

Much has been said about waste elimination and the necessity for systematized salvage and reclamation. That advice was greatly needed and has doubtless done much to reduce needless expense. It should be remembered, however, there is a point beyond which salvage or reclamation become unprofitable. An ordinary pipe wrench, globe valve or grease cup, for instance, may be only slightly out of repair and it seems a shame to discard the piece as useless. But calculate the cost of a workman's time in putting the piece back into shape against the cost of a new piece, and the results will frequently indicate the purchase of new equipment as the more economical way out.

Nails, bolts, bars, chisels, wood screws, nuts and other simple forms of equipment nearly always justify salvage effort or at least the consideration of reclamation costs. Doubtless the annual waste in such small parts, due to careless handling, mislaying, unwise issuance, corrosion, etc., runs into the millions of dollars—much of which might be saved through increased attention and systematic organization. As for old and decrepit machinery, however, the cost of patching and repair frequently exceeds the cost of new equipment—with no possibility for increased efficiency or lasting investment.

It is a duty of management to instill into every employe the realization that waste, in whatever form, militates as much against himself as the company, and that no individual, company or nation is rich enough to tolerate it.

Chicago, Ill. Wm. Sibley.

Receiver Pressures for Compound Engines

Again the question of proper receiver pressures for compound engines is brought up by G. Reed's excellent article on page 427 of the April 1 issue. From a theoretical and technical standpoint the contribution is good and worthy of study by young engineers who would become something more than workmen and operators around the power plant. I would like to add a few words from the so-called practical side of the subject, the actual obtaining of the desired or required receiver pressure in any given engine.

In practice there are three things that must be considered in relation to receiver pressure; that is, equal power, equal initial stresses and the development of power with minimum steam consumption. From an operating standpoint we are concerned with the first and third only, as the second is a matter of machine design.

In cross compound engines it is generally considered that the receiver pressure should be such as to produce equal power in both cylinders. This is accomplished by taking indicator cards, making calculations for power and then making adjustments in the low pressure cylinder cutoff gear, either to shorten or lengthen the cutoff in that cylinder. Shortening the cutoff builds up the receiver pressure and increases the back pressure in the high pressure cylinder, therefore decreasing the power output of that cylinder. At the same time, the power output in the low pressure cylinder is increased. By taking a few sets of indicator cards and making the adjustments after each set has been taken, the power can be equalized as desired.

In the case of the tandem compound engine, there is really no absolute necessity for equal power in the cylinders and the receiver pressures may be adjusted so that the governor will float in the highest position for the load the engine carries the greater part of the time. This means the lowest point of steam consumption, which is, of course, the important part, although it is sometimes advisable to sacrifice a small advantage in steam consumption to obtain smooth or proper running of the engine and reduce maintenance on the engine.

Brooklyn, N. Y. Chas. J. Mason.

Changing Speed of Engine

Not long ago I was requested to change the size of the governor pulley on a large 24 and 48 by 60-in. tandem compound engine so that it would boost the speed of the engine 10 r.p.m. This pulley, which drives the governor shaft, was 16 in. diam. It is driven by ropes which run in grooves in the 12 in. diam. shaft of the engine.

The governor mechanism had a gear shift which allowed speed changes of 60, 70, or 80 r.p.m. It was desired to increase these speeds 10 r.p.m. in order to increase production in the mill. I had noticed that the revolutions of the governor balls was constant at 60 r.p.m. for all three speeds, so I figured that all I had to do was to change the size of pulley wheel so that with an increased speed of the engine shaft of 10 r.p.m., the governor would still rotate at 60 r.p.m. In other words, the speed of the pulley would not change. The ratio of rotation of the shaft and pulley was 80 r.p.m. $\times$ 12 in. diam. shaft = 60 r.p.m. $\times$ 16 in. diam. pulley, hence, to determine the diameter D of the pulley required for the increased shaft speed of 90 r.p.m., we would have

$$90 \times 12 = 60\ D \text{ or } D = \frac{90 \times 12}{60} = 18 \text{ in.}$$

We made the new pulley 18 in. diam. and obtained an engine speed very close to 90 r.p.m.

Dayton, O. J. A. Barnard.

Lubrication Should Be Intelligent

PROPER LUBRICATION is receiving a constantly increasing degree of attention but needs even more to make new converts to correct practice and prevent backsliding.

One forward step is realization that machinery can have too much lubricant. Insistence of manufacturers that motors needed attention and that lubrication must not be forgotten, resulted in the past that the maintenance man considered that, "if the motors needed oil, by gosh, he would oil them plenty." Result—oil in windings, on brushes and slung about generally.

Realization has come that too much oil can be detrimental, which augurs well for increased life of equipment.

Another advance is comprehension that oil is not just oil. There are oils—and oils—yes and greases. One kind will not suffice for all purposes. For various bearings—high-speed with high pressure, high-speed with low pressure, medium-speed with medium pressure, low-speed with high pressure and special cases, different lubricants are needed.

Sufficient viscosity for a big boring mill would be out of place on loom spindles. Bearings for shaft hangers, for lathes and for rolling mills do not call for the same consistency of lubricant. Too viscous a fluid retards motion though it may furnish lubrication. Too thin a fluid is squeezed out and doesn't lubricate.

Knowledge as to proper practice is easily had from qualified lubrication engineers, usually obtainable from reliable oil companies at little or no cost. Periodic check ups on practice and conditions will often reveal waste and astonishing opportunities for economy.

WILLIAM SIBLEY

Stethoscope Used to Detect Unusual Noises

DURING THE PAST 20 yr. I have seen at least a dozen different designs of more or less complicated sound intensifiers or detectors suggested for use in a power plant. Most of these detectors required the use of telephone receivers, radio ear phones or similar devices.

Unusual noises in engines and similar machines may be readily detected by means of a physician's stethoscope of the cheap ordinary type.

I have found this simple instrument very effective for the purpose.

Toronto, Canada. JOHN THORN.

Red Tape Is Sometimes Expensive

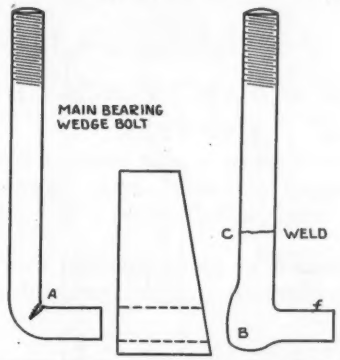
ON ONE OCCASION the writer drew a die stock out of a tool room on three checks, one for the stock, the second for the collar and the third for the die. At the close of the year when the check inventories were taken, I found that I had lost the collar. In quantity production, this would be worth about 10c. I reported it to my foreman, who always stood pat with his men—first, last and all the time. He said, we'll cut out all "rag-chewing" about the diestock collar; he told me to put in another tool check, get another collar and issue a shop order to "Repair collar." I was told to take this to the foreman of the machine shop and tell him to make a new collar. The new collar was turned out of solid stock, involving about one-half a day's time of one man and costing the company about $3.00.

This illustrates the inadvisability of dwelling too rigidly on red tape methods, which is an attitude frequently assumed by persons who owe their position to circumstances of choice other than of ability and thorough knowledge of the business.

Pittsfield, Mass. T. H. REARDON.

Overcoming Wedge Bolt Breakage

WE HAVE HAD much trouble with main bearing wedge bolts breaking at the bend A, shown in the cut figure. We have overcome this trouble by having the blacksmith make a forging from heavy stock, increasing the thickness at the heel B. This forging had to be machined



FORGING BOLT WITH ENLARGED HEEL STIFFENS IT AT POINT WHERE MOST STRESS IS APPLIED

where it enters the wedge and welded onto the shank as shown at C. This last operation was made necessary on account of the required machining operation.

Anderson, Ind. J. O. BENEFIEL.

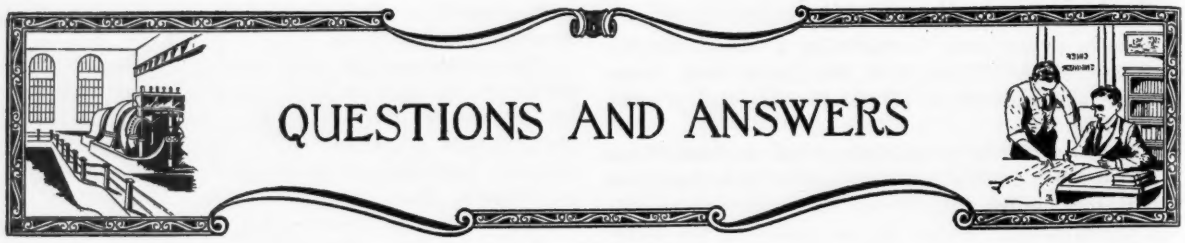
Method of Inserting Large Thin Gaskets

BECAUSE of its low price, a roll of 1/32-in. sheet rubber packing was purchased by the manager of our power plant. Shortly afterward a couple of flanges on a 14-in. vertical line of pipe required new gaskets. After wedging the flange faces apart about ⅜ in. and scraping the faces of the flanges until they were clean, I attempted to insert the gaskets which I had cut from the above mentioned thin sheet rubber packing, but it was so flexible that I could not place it into position.

Two gaskets were then cut from stiff wrapping paper and four gaskets from the thin sheet rubber. Each side of the paper gaskets were then given a coating of thin glue and attached to a rubber gasket on each side. This gave gaskets a little more than 1/16 of an inch thick and the addition of the paper and glue made the washers so rigid that their insertion between the flange faces was a simple matter. The pipe carries 150 lb. steam pressure, and the joint made as above described remained steam tight for many years.

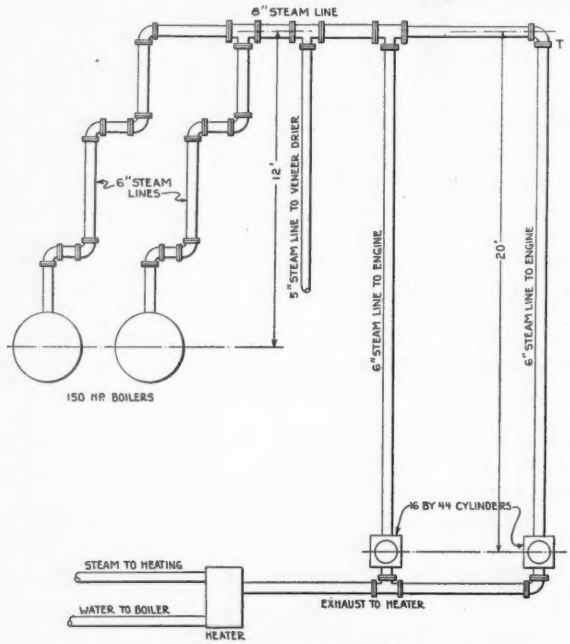
Thin asbestos paper could be used in place of the wrapping paper; the glue when given a little time to harden will stiffen the paper and the result is a very fine gasket.

Toronto, Canada. JAMES E. NOBLE.



Condensate in Long Pipe Lines Causes Trouble

WE WOULD LIKE to have your suggestion relating to one of our steam problems. Our power plant layout is illustrated in the figure herewith. We have trouble with



LAYOUT OF STEAM PIPING

water coming over in slugs into the engine. This water does not come over all the time, but it will start without any apparent cause.

We have no domes on our boilers nor steam separators on our steam lines. We use silicate of soda for a boiler compound and there is no oil in the feed water. The water comes over whether or not we have a load on the engine. J. M. A.

A. Your layout would indicate the probability of collecting condensate particularly in the 8-in. steam line. When the quantity of this water becomes sufficiently large, the pulsation caused by the uneven demand for steam by the engine, especially when there is a sudden increase of demand, such as when the load is suddenly increased, would cause slugs of water to be drawn over into long vertical pipe to the cylinder.

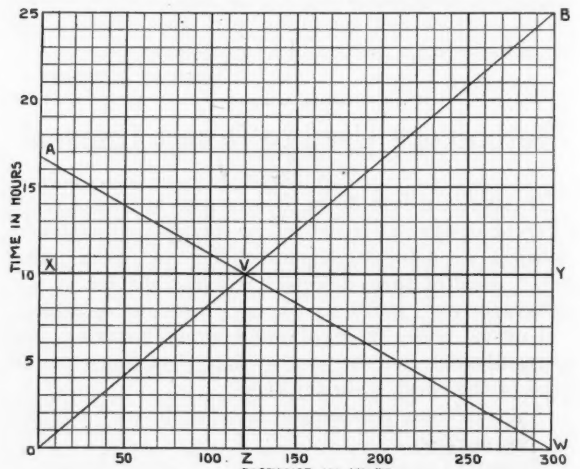
If you drew your steam from the top instead of from the bottom of the 8-in. line and of its extension, and placed a drip pocket with a trap at its lower end at T, the extreme end of the horizontal steam line, you would decrease your trouble but it would be better still to install receiver-separators just above the cylinders so that the steam would be drawn into the cylinders without causing pulsation in the long steam lines and the water would be removed by the traps as it collected.

If it is possible, better effect is obtained when the steam lines between boilers and engines are made as short as possible and when they are properly insulated.

Solving Rate Problems Graphically

HOW CAN I FIND the rates of speed of A and B under the following conditions: A and B start at a point 300 miles apart and traveling toward one another meet. After meeting, it takes A 6⅔ hr. to complete the distance just traversed by B and 15 hr. for B to complete the distance just traversed by A. J. E. C.

A. This is a problem for the calculus, but it can be easily solved graphically as shown in the illustration by laying off X Y horizontally, representing the division of the journey at which A and B met; by pointing off O W in units representing the entire distance traversed = 300 mi.; XA in units representing 6.66, the time



INTERSECTION OF TWO RATE LINES DETERMINES RESPECTIVE DISTANCES TRAVERSED

required by A to finish the journey; and VB in the same units representing 15, the time required by B to finish the journey.

Now taking two narrow strips of heavy paper or thin card board having a line drawn along their centers, insert pins at the ends of each through the lines and then insert the pin of one at A and the other at B. Swing these two strips around until the lines on the strips cross at the intersection of line XY and at the same time also crossing the lines OA and WB at points that would lie horizontally as OW. Point V then represents the juncture and WZ and OZ represent the respective distances traveled by A and B to the meeting point.

To complete the journey, B therefore goes a distance ZW = 180 mi. in 15 hr., hence B's rate will be 180 ÷ 15 = 12 mi. an hour; while A goes a distance of ZO = 120 mi. in 6⅔ or 6.66 hr., hence A's rate will be 120 ÷ 6.66 = 18 mi per hr.

Comment on Water Backing Up into Engine

In answer to C. L. P.'s question in the January 15 issue, I would state that there are two ways to supply water to a barometric or siphon condenser. We may pump the water into the condenser or we may use a tank, placed 10 or 15 ft. below the water inlet to condenser, in which case the atmospheric pressure forces the water into the condenser, that is "siphoning" it in.

In starting a siphon condenser we may use forced injection or a cross-over valve to create the vacuum. The danger with forced injection is that it may admit more water than the tail pipe (discharge pipe) can carry off; or we may forget to cut out the forced injection after barometric action has started, hence the water will accumulate and run over into the exhaust pipe. Then, as the exhaust valve opens, the water will flow into the cylinder. Such a solid body of water would break something by "water hammer" action. This is especially true where we are using condensers having narrow necks or "throats" which are used to increase the velocity of the water. I believe all barometric towers have traps at the bottom part of the exhaust pipe, but no trap could take care of all of the water carried over as described above.

Roxbury, Mass. Charles Magnus.

Choice of Boiler Pressure for Steam

What would be the difference in the temperatures and degrees of superheat of steam which has passed through a reducing valve from pressures amounting to 100 lb. gage and 60 lb. gage to 14 lb. gage? C. B. S.

A. At 100 lb. gage or approximately 115 lb. absolute the total heat, according to the Steam Tables by Marks and Davis, is 1188.8. Similarly for 14 lb. gage or 29 lb. absolute the total heat is 1163.2. The difference, 1188.8 — 1163.2 = 25.6, represents the total heat of superheat, assuming dry and saturated initial condition. The specific heat of steam may be assumed for the moment as being 0.5, then the approximate degrees of superheat would be 25.6 ÷ 0.5 = 51.2. Now, consulting the diagram on page 97 of Marks and Davis Steam Tables, we find that for a temperature of 229.6 deg. and a pressure of 29 lb. per sq. in. the specific heat at constant pressure is 0.48. Using this correct value, we have 25.6 ÷ 0.48 = 53.5, which is the actual degrees of superheat. The temperature corresponding to 29 lb. absolute, which is approximately 15 lb. gage, is, according to the tables, 248.4. This would give a temperature of 248.4 + 53.5 = 301.9 after passing through the valve.

Similar values may be obtained from the Total Heat Entropy Diagram as follows: Locate the point on the "dry and saturated steam" line where the 115 lb. pressure line crosses it. Trace this point horizontally to the right, assuming constant entropy, until the 29 lb. pressure line is crossed, then read the corresponding degrees of superheat which will be found to be 53.5, the point of intersection falling between the 50 deg. and 60 deg. constant superheat lines.

Likewise, for a supply pressure of 60 lb. per sq. in. we would have:

1181.1 — 1163.2 = 17.9 = total heat of superheat.

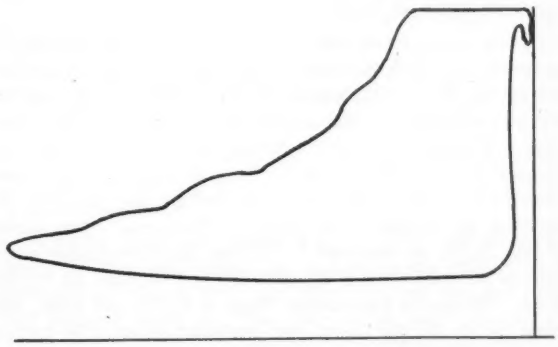
17.9 ÷ 0.5 = 35.8 = approximate superheat.

Consulting the diagram, we find the correct specific heat to be practically the same as before, i. e., 0.48, hence the actual superheat will be 17.9 ÷ 0.48 = 37.4 and 248.4 + 37.4 = 285.8, represents the temperature of the steam immediately as discharged through the reducing valve when the original conditions of the steam was dry and saturated at 60 lb. per sq. in. pressure. In either case this superheated condition can be considered to exist only in the immediate vicinity of the reducing valve.

Defective Valve Setting and Indicator Motion

Please let me know what is wrong with the indicator card herewith. It was taken from the crank end of a 14 by 30-in. double ported Corliss engine running at 136 r.p.m.? J. M. K.

A. The card indicates faulty valve setting and defective indicator pencil motion. It would be best for



you to reset your valves completely. Release, compression and admission are too late. You may remedy these defects by advancing the eccentric.

The "hook" is due partly to too late admission and partly to irregular pencil motion. The former effect is no doubt increased by wiredrawing at the beginning of the admission steam.

You should first inspect your indicator to see that all parts move freely but without loose joints and then reset your valves in the regular way.

Locating Pump for Brine Circulation

What is the most economical way to connect up a multipass brine cooler using a centrifugal pump for brine circulation?

A. The brine pump is usually located at a level a little lower than the bottom of the brine cooler from which it takes its charge. The cooled brine is pumped to the freezing tank or storage room, as the case may be, and, after passing through the latter, returns again to the brine cooler.

EDITORIAL COMMENT

The Bugbear of Midwest Coals

Mention of Midwest coal to the average engineer has the same effect as waving a red flag at a bull or holding a fat and bulging capitalist up before a meeting of radical laborites. Words may differ with the vocabulary of the individual but action and sentiment never. A few low inarticulate rumbles, a quick scrutiny to determine the ulterior motive and then whether there is an ulterior motive or not, a rush of words to deny that such coal will ever be of any use except in the hereafter.

Two Illinois and Western Kentucky coals rightly come within this general classification, but through the more or less widespread use of the better grades, have acquired an individuality, leaving the Iowa, Missouri, Kansas, Oklahoma and Arkansas coals to bear the brunt of the battle. These coals are not all "bad," in fact some of them run up to nearly 14,000 B.t.u. All of them, however, even from the same field, show a wide variation, not only in chemical analysis, but in burning characteristics as well.

That these coals can all be burned successfully if properly handled on suitable equipment is shown in the article by E. L. McDonald in this issue, giving operating experiences on chain grates at the Northeast Station. Underfeed stoker operation with southeastern Kansas "Cherokee" coal at Neosho Station was mentioned by C. F. Tomlinson who, before the A. S. M. E. meeting at Kansas City said: "The coal runs about 11,000 B.t.u. as received * * * but it is extremely variable as we have had it below 9000 and as high as 13,000 B.t.u. Moisture has varied from 6 to 16 per cent, ash from 10 to 21 per cent and sulphur from 2.76 to 5.8 per cent. * * * Some burns slowly, some fast, some cokes and some does not, some clinkers and some does not, etc. With its poor quality and variations, however, we have been able to burn it, at ratings up to the limits of our uptake draft, with results we consider good. During a 16-month period in 1925 and 1926 we operated our boilers at an average rating of 190 per cent and a maximum of 250 per cent. The boiler efficiency averaged 76 per cent, while the CO_2 in the uptake was 12.6 per cent and the combustible in the refuse 22 per cent."

At the Des Moines City Railway plant, Iowa coal averaging 9000 B.t.u. is burned on natural draft chain grate stokers. Boiler ratings of over 200 per cent are obtained and nearly 50 lb. of coal per sq. ft. of grate area can be burned. The yearly efficiencies of boiler furnaces and grates average well over 70 per cent and show an evaporation of about 6.25 lb. of water per pound of coal. These results were reported by T. H. Marsh before the recent Iowa Power Conference where he also stated that many failures to burn this coal in the past were due to poor design, brought about by lack of knowledge of combustion and information regarding the characteristics of the fuel.

Pulverized coal has also been successful in this Iowa district. A unit pulverizer installation operating many months at the Des Moines Water Works shows consistent evaporation averaging about 6.25 lb. of water per pound of coal or from .50 to 1.25 lb. more than does the similar chain grate units in the same plant. Coal with a monthly average as low as 7600 B.t.u. has been burned successfully.

At the Big Sioux Station Iowa coal was burned during the month of February, 1927. The average analysis was 9100 B.t.u. with 18 per cent ash and a boiler efficiency of 84.5 per cent was maintained. During the month of April, 1926, the major portion of the coal burned was from Iowa and this month's efficiency was the best in the history of the station. They report no difficulty in operating at rating as high as 350 per cent with Iowa coal.

Results in Lakeside and Cahokia show the possibilities of burning low grade mid-western coal in pulverized form while both the Moline-Rock Island Mfg. Co. and the Kansas City Light & Power Companies are experimenting with unit pulverizers. Number 1 furnace at the Northeast Station is being remodeled and equipped with air cooled walls, radiant superheaters and water screens for use with two unit pulverizers.

In fact, the ease with which other coals could be substituted when trouble was encountered with the Midwest coals has been the big factor in holding back experimental work to remedy the difficulty properly. In spite of this, the mechanical and technical difficulties, with the exception of storage which can be successfully handled only under water, have been solved and the problem from the standpoint of the power plant turned into one of economics rather than engineering.

Until this coal has a decided advantage on the B.t.u. basis over better coals from other fields, there is little possibility of increasing its use. Equal value is not sufficient. There must be considerably more than equal value and some guarantee of future values in order to overcome prejudice and make it profitable to undertake the engineering and construction changes necessary for burning it.

Labor and freight are, of course, the major items which the coal operator must consider. Efficient and modern production methods, however, are factors worthy of consideration, and the extent to which they have been adapted to other fields is evidence of their ability to reduce costs.

As brought out very forcibly at the Iowa Power Conference, the problem of burning Mid-western coals no longer rests with the engineer, but is squarely up to the mine operator. At present prices, the market for these coals is decidedly local; small outputs and geological formations make quantity production on an extensive scale unprofitable. Low production cost depends upon large sales and large sales in turn depend upon

low production cost. To break this apparently hopeless circuit, the mine operators must look forward and devise some method of lowering the cost in order to broaden the market either by labor or railroad legislation or lower operating costs or by sacrificing profit for a period of years until the market is developed.

The Perfect Boiler House

One item we did not find at either the recent New York or the Chicago power shows was the "perfect boiler house," considered to be one of the most interesting features at the British Industries Fair, held in Birmingham, England, from Feb. 21 to March 4. This was erected in the power plant division of the Birmingham exhibit through the co-operation of over 30 British manufacturers of power plant equipment.

In this perfect boiler house, full-sized boiler and prime mover equipment was shown in full operation. The display included a water tube boiler equipped for powdered fuel firing and a Lancashire boiler with mechanical stokers, both exhibits being completely fitted with superheaters, economizers, pumps, fans, water softening plants, control instruments and other auxiliaries. The engine room contained two turbo-generators, two reciprocating engine generators and auxiliaries, such as condensers and pumps, water cooling tower, transformers, indicating and recording instruments.

Grouped around these large central exhibits but separated from them by gangways for visitors were the booths of the representatives of the firms which contributed to this joint scheme. In organizing the exhibits, duplication of the various items was avoided as far as possible so that visitors were able to inspect alternative types.

In view of the increasing interest in the various power shows, the arrangement outlined above is particularly noteworthy. Inspection of various individual pieces of equipment in operation or models of them has great value but this value is greatly increased, it seems to us, if they can be shown installed and operating in conjunction with the other apparatus in the power plant, thus presenting a correct picture of the power plant, which must always be considered as a unit.

Whether or not such an exhibit of equipment as was shown at Birmingham could be arranged for the power shows in this country is another question. There are several companies, of course, that manufacture sufficient equipment, with the exception of a few accessories, to set up a complete boiler plant. Many business factors, however, entirely apart from the engineering phases, would have to be considered. In addition, the physical conditions in the various exhibit halls that are used might make it impossible to set up a complete boiler with its auxiliaries in an exhibit hall, although this difficulty would not be encountered with the smaller sizes of turbo-generators and reciprocating engines. In addition, the objection might be raised that, after viewing such an exhibit, some people might thereafter associate together the particular types and makes of equipment grouped together, forgetting that other combinations might be possible. Careful balancing of its advantages against its disadvantages, by some manufacturer or group of manufacturers, might reveal that such an exhibit could be arranged.

Organizing Against Fire

Industrial plants in providing against destruction by fire usually give all attention to fire fighting. A few give some consideration to the guarding of property during a fire. A very small percentage give regard to fire prevention. None provide for salvaging.

Efficient organization against fire includes all of the above factors. In each case the following steps should be carried out:

1. Organize and plan;
2. Select personnel based upon fitness;
3. Designate definite duties;
4. Train for efficient service.

Guarding should be not only for the protection of material that has been salvaged but to prevent unauthorized persons from obstructing passage ways, hindering the work of authorized persons and becoming potential sources of unnecessary losses.

Training for salvage work is essential as will be appreciated by all who have witnessed the tossing of breakable material from a window by excited persons, while unbreakable articles are carefully carried down stairs. Under these conditions, who has not seen equipment that would not burn destroyed by well meaning but untrained persons when all the really valuable matters such as papers could have been easily removed in drawers. A salvage corps should be trained to know what papers or other matter should be locked in a safe and what tools or equipment are of most worth in any department and how they should be handled during removal.

Water does more damage than flame at many fires. Tarpaulin properly and promptly placed may prevent much unnecessary loss.

Proper training, which will involve regular drills, prepares the individual for subconscious action in an emergency. Those who have this training will not flounder around when the time for action arrives, but will know how and when to act with directness and dispatch. For this reason those who lack this special training should not be allowed to be on the premises during a fire. A few well trained men are worth much more than a vast number of men without special training.

Preventive measures are more effective than those of restoration. Little thought, however, is given to fire prevention in plants, probably for the same reason that the Arkansas countryman did not repair the leaking roof of his hut. Recently the writer visited the boiler room of a fine wood working plant in which refuse was used as fuel. All around on top of the feeding device and the face of the boiler just above the fire doors, a large accumulation of very fine wood dust was found. Anybody who has read Price and Brown's book on Dust Explosions will appreciate how easily the combination of an open fire door and a stirring up of this fine dust, as by a sudden draft or a shaking of the building, would result in the loss of a fine boiler plant.

Characteristic of those who give little thought to preventive measures, the boiler house of the plant referred to carried no insurance because "the rates were too high."

Varied Program at Kansas City Meeting

MANAGEMENT AND EDUCATION SESSION COMBINED WITH PETROLEUM, POWER AND FUEL SESSION CREATES WIDESPREAD INTEREST AT THE A. S. M. E. REGIONAL MEETING

MEMBERS of the A. S. M. E. gathered at Kansas City, Mo., for the regional meeting, April 4 to 6, enjoyed a varied program which included, in addition to the papers presented, inspection trips to various plants in the city.

Education and training for the industries were discussed in a session on the afternoon of the first day. F. W. Thomas explained in detail the railway apprenticeship system used by the Sante Fe Railroad, while foremanship and management training were discussed by L. A. Hartley. The specialized requirements that must be met today give rise to need for general education of the public as an economic basis of industries and requires more complete and thorough job training and education for industrial leadership. These points and their relation to each other were brought out by C. F. Walker.

Three simultaneous sessions were held on the second day; management, petroleum and power. Industrial management in general was discussed by James McQueeney, railroad shops and terminals by W. R. Harrison and personnel administration in the steel industry by F. V. Larkin.

At the petroleum session different drilling and pumping rig equipment were described by G. McConnell, with particular reference to a new universal drilling machine driven by electric motor. Electrification of the oil field is becoming quite general and the various applications were covered in some detail by G. M. McCargar. Advantages of the double rated two speed motor, the double rated single variable speed motor and the double rated single constant speed motor were pointed out and their relative costs and effects on the system load explained.

DIESEL ENGINE LUBRICATION DISCUSSED

Lubrication of Diesel engines is receiving considerable attention and was discussed by W. O. Northcutt, principally from the standpoint of oxidation of the oil and methods of preventing this oxidation taking place before the oil reaches the cylinder. Lubricating devices to accomplish this were explained and introduction of the oil above the piston rings was advocated. In a general discussion following this paper, it was generally agreed that oxidation should be prevented as far as possible, but that introduction of the oil below the rings was preferable. Furthermore, lubricating oil is often blamed for difficulties which arise from dirty fuel, dirty lubricating oil or dust in the air.

In the power session, treatment of feed water for industrial and power plant boilers was covered in a very comprehensive paper by S. T. Powell, following which present tendencies of steam station design were presented by V. E. Alden, who outlined the objectives of the modern engineer, sketched a typical plant of 1913 and, with a very logical development, showed the effect of each single item upon the improvement of central station design as a whole.

SYMPOSIUM ON MIDDLE WESTERN PLANT DESIGN BRINGS OUT INTERESTING FEATURES

Following Mr. Alden's paper, a symposium on steam power plant development in the middle west brought out some features illustrating why fuel, load and regional conditions necessitated some deviation from standard eastern practice. F. S. Collings by means of curves explained why 500 to 600 lb. is the economical pressure for large stations and reviewed briefly the effect of fuel on design. Design trends in the Kansas and Missouri section were covered by C. S. Tomlinson and the importance of spray and cooling ponds pointed out.

Pulverized coal was considered in discussions by E. H. Tenney and K. M. Irwin, the former considering results of tests at Caliokia and their application to the entire middle west, the latter giving experiences at the Big Sioux station.

Low temperature distillation processes were considered in a paper by Dr. Runge, from an economic rather than from a technical standpoint. In a written discussion, A. G. Christie brought out the fact that considerable educational propaganda must be carried on to make the fuel so produced attractive to the average householders and also the importance of directing attention to the economic side as there is danger that new processes may be ruthlessly exploited by financial promoters.

Experiences and data on burning of midwestern fuels in the Northeast station of the Kansas City Power & Light Co. were given by E. L. McDonald. Fuels in this territory differ widely in characteristics, although they can all be burned successfully with proper equipment and conditions.

Fundamentals of industrial furnace design and operation were discussed by V. J. Azbe. In the case of many furnaces and kilns working temperature levels are high, ranging from 1000 to 2000 deg. F. making high efficiencies difficult and losses due to excess air or

radiation considerable. Particular conditions of design and operation complicate the problem, and in many cases the efficiency is no higher than 10 per cent. Mining methods and mechanical means of production and distribution of coal from the various midwestern fields were described by C. M. Young.

Problems of particular interest to the Kansas City Section were considered in a separate session, where protection of mills and elevators against fire and explosion was covered by F. G. Hoxie, mechanical engineering features of flour milling were pointed out by M. B. Bell, and the application of machinery to agriculture explained by O. B. Zimmerman, who gave particular attention to methods of eradicating the corn borer. This worm is susceptible to heat or injury so that burning and mechanical vibration are both effective. The mechanical machine consists of a number of revolving knives spaced ⅜ in. apart to shred the stalk thoroughly to below the ground and is the more practical and economical method.

Iowa Inaugurates Power Conference

NATURAL RESOURCES OF THE STATE AND THEIR RELATION TO POWER DISCUSSED WITH PARTICULAR ATTENTION GIVEN TO WATER POWER AND THE UTILIZATION OF LOW GRADE COAL

PRODUCTION and utilization of the natural resources of Iowa and the generation and distribution of electric power throughout the state were discussed in detail at the Iowa Power Conference held at Iowa City, Iowa, March 30 and 31, under the joint direction of the College of Applied Science and the Extension Division of the University of Iowa. Hydroelectric power, transmission systems, inter-connection, rate setting and legislative regulation were considered in some detail while the mining, burning and utilization of Iowa coal had a prominent part on the program. Other state resources such as the rock and cement industries and the commercial importance of power in the development of industries outlined.

In dealing with statistical data, Joe Carmichael brought out the fact that 99.7 per cent of the urban population of the state are served by electric power, while 72.3 per cent of the industry of the state is electrified as compared to the average of 66 per cent for the United States as a whole. Only twelve of the 39 privately owned electric light and power companies have generating equipment. The locations of these stations and high tension distribution systems were shown by J. R. Eyre on a large scale map.

ECONOMIC CONSIDERATIONS PREVENT DEVELOPMENT OF MANY POWER SITES

Water power is an important item in the state and from a paper by F. A. Nagler, it will probably be possible to develop at least 400,000 hp. energy from the streams within the state. Channels of Iowa streams fall between one and 8 ft. per mi. and large storage reservoirs for flow regulation are impractical.

In discussing this paper, W. C. Tegtmeier explained some of the practical difficulties encountered and the exorbitant prices demanded for overflow lands. There are many advantages in having a number of small developments in strategically located points in the operation system because it eliminates cost by transmission lines, and gives an opportunity to take advantage of diversified and local rainfall. Water power is used principally to cut peaks and has made it possible to carry practically a straight line or unity demand with the transmission system.

Recent developments in transmission systems were covered by H. R. Summerhayes. Maximum transmission voltages steadily increased to the present 220 kv. and no difficulty is anticipated with higher voltages. Interconnection by adding mileage in transmission lines increases the area subject to lightning and other disturbances, and tends to cause more interruptions in service unless the relay system is carefully designed.

SLEET FORMATION ON WIRES PREVENTED BY HEATING WITH EXCESSIVE CURRENT

Importance of standardized voltage was emphasized by D. O. Sutherland who also outlined some difficulties of sleet formations. Experiments with a machine to dig holes up to 36 in. in any soil have been successful and indicate a saving of approximately $0.53 per pole.

Perhaps no other factor contributes more potently to the use of electric energy than does an equitable rate structure and the fundamentals of power rates were given by C. C. Williams. Three fundamentals enter into the cost of service: first, production cost including a fixed charge; second, a proper return on the fair value of property, and third, a just reward to the business ability required to operate the business.

"Power Station Interconnection in Iowa," by A. H. Ford, considered the problem from two important standpoints, economy and dependability. Practically the entire state could be interconnected by building a relatively small number of 13,200-v. lines. Discussions by R. H. Garrison and John A. Reed brought out the fact that under present Iowa conditions where loads are small, interconnection with the larger stations is not always economical and a number of small plants carefully located offer superior advantages both from a standpoint of cost and flexibility.

CHAIN GRATES WELL ADAPTED TO IOWA COAL

A very comprehensive review of the mining conditions in the state was given by J. H. Lees. Iowa coals are relatively soft with high sulphur and ash content with a percentage of volatile nearly as high as that of the fixed carbon. They do not stand air storage well but comparative analyses with Illinois coals show that the two do not differ greatly in heat content and chemical composition. Practical difficulties encountered when using Iowa coal were mentioned by T. H. Marsh. Many of the early designs of grates and furnaces were in error, and failures to burn the coal properly were due to lack of thorough knowledge regarding the fuel characteristics, lack of knowledge regarding combustion and the ease with which other coal could be substituted when trouble arose. Pulverized fuel has been used and is evidently the ideal method for utilizing Iowa coal which suffers from an inferiority complex due to the fact that its disagreeable and poor qualities have been more widely broadcasted than its good qualities. Pos-

sible research to discover more fully the good qualities and lessen the handicap were outlined by C. F. Fleming, who mentioned washing, cleaning, pulverizing, carbonization and improved equipment.

Practically All Problems Economic Rather Than Mechanical

Importance of efficient and modern methods of mining were discussed by F. H. Buhlman, while J. A. Drabelle drew attention to the fact that the one item which must be kept in mind regardless of coal or conditions is the total cost of making 1000 lb. of steam. In fact, general discussion throughout the entire conference pointed to the fact that the problems of interconnection, hydroelectric development and use of Iowa coal are largely economic rather than mechanical.

Stratton Furnace Burns Crushed Coal in Suspension

DESIGNED FOR the burning in suspension of coal that has been crushed to ¼ in. size with its accompanying fines and employing only a mechanical coal feeder and a specially designed throat at the bottom

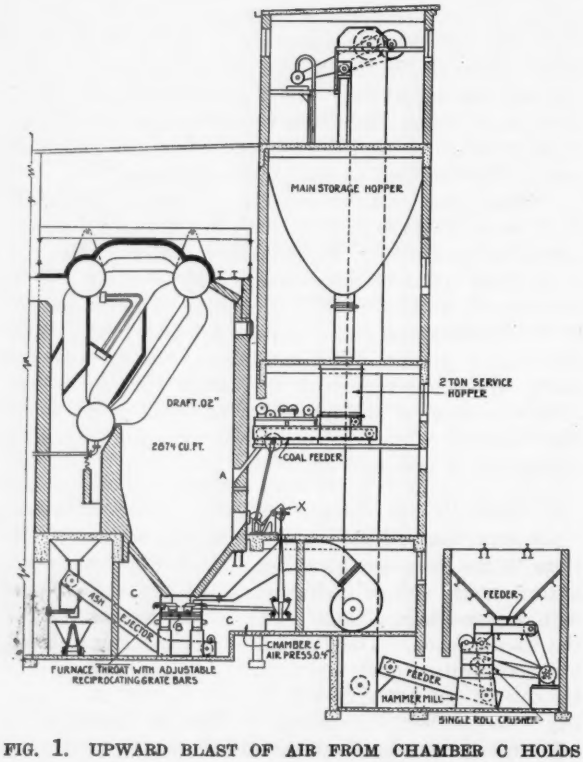


FIG. 1. UPWARD BLAST OF AIR FROM CHAMBER C HOLDS BURNING PARTICLES OF COAL IN SUSPENSION, ASH DROPPING THROUGH BARS AT B

of the furnace, in addition to a standard type of coal crusher and a blower, the furnace shown in the accompanying illustrations is now being put on the market after exhaustive tests of installations under actual operating conditions.

In designing this furnace, the object of the inventor, J. F. O. Stratton, was to obtain the same results secured with pulverized coal but at less cost, by burning crushed coal in suspension. The basis of the system is the separation of ash from incandescent coal by an air blast; the ash, being considerably heavier, falls into the ashpit against an upward blast that is sufficient to support the burning fuel in suspension. Coal crushed to ¼-in. size, will float when incandescent in an upward blast equal to the nozzle velocity produced by a pressure differential of 0.4 in. of water. This pressure, however, will not support the ash.

Accordingly, the furnace of the general type shown in Fig. 1 was designed to utilize the above principles. Coal crushed to ¼ in., together with the fines, is delivered by the most convenient method to the coal feeder and thence to the coal nozzle A, where it drops into the

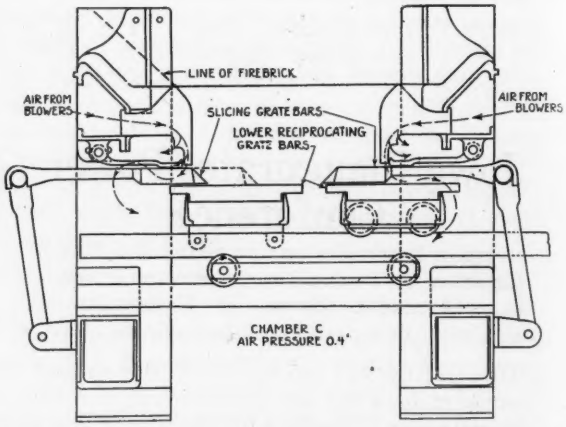


FIG. 2. DETAIL OF THROAT, SHOWING HOW SLICING BAR CLEANS OFF LOWER BAR, BOTH BEING RECIPROCATED IN OPPOSITE DIRECTIONS

furnace by gravity. The coal is not dried. Assuming that there is already a fire in the furnace, the fines burn at once near the nozzle and the larger particles begin to fall, igniting and burning in the process in the stream of air that is coming up through the throat B from the chamber C, in which an air pressure of about 0.4 in. of water is maintained by a blower of the requisite capacity.

In this throat are two sets of reciprocating grate bars, one working over the other, as shown in Fig. 2. These bars have a 6-in. stroke, make three strokes a minute and are designed so that the top bars in coming forward will push off into the air stream any coal or ash that may drop there, thus preventing clinker formation and allowing the coal to be blown upward and burned and the ash to drop through the opening. This opening can also be regulated in width to suit the given conditions. The reciprocating grates are driven through a link motion, as shown in Fig. 1, with levers X for adjustment.

As explained above, the chamber C is under air pressure of about 0.4 in. all the time. This air, forced in by a blower, enters through tuyeres or nozzles of which the throat is composed, serving to cool the throat and grates and also to preheat the air somewhat.

The design provides for only a comparatively small amount of coal to be accumulated in the furnace at any time, depending, of course, on the amount of load and

this gives quick control in both starting and stopping the fire. It has been possible with this furnace to bring a boiler on the line from cold to normal rating in 20 min.

In the installations of this furnace now in operation, little slag is evident. These furnaces have operated at the plant of the U. S. Gypsum Co., Oakfield, N. Y., for about one year, with 508-hp. boilers operating at 350 lb., and at Poehlman Bros., Morton Grove, Ill. for about 7 mos., with 600-hp., 140-lb. boilers.

The entire setting is of solid refractory brick construction except for the air-cooled cast-iron throat at the bottom. The feeder mechanism and grate mechanism can be driven from a steam engine or a motor, to which automatic control can be applied if desired. This control can also be applied to the blower, placed in any convenient location, so that any change in coal feed will be accompanied by a corresponding change in air supply. Ash is removed from chamber C by any desirable method, the one shown in Fig. 2 being a mechanical ejector.

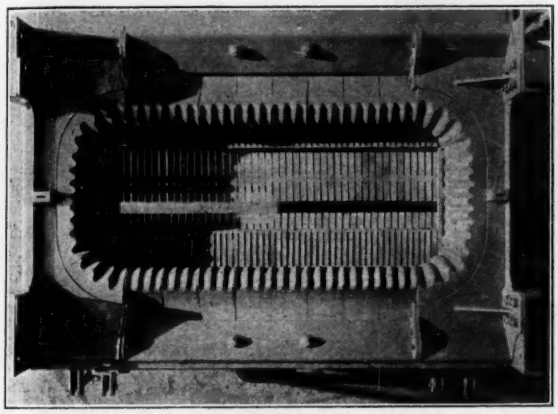


FIG. 3. LOOKING DOWN ON CAST-IRON THROAT, SHOWING AIR INLET NOZZLES AND THE TWO SETS OF RECIPROCATING GRATE BARS

This system is designed to be installed either with a central crushing plant and storage hoppers or as a unit system in front of each boiler.

Flow meter charts from boilers in the present installations show that they have been operated with these furnaces at from 75 per cent to 300 per cent of boiler rating. The furnaces are being placed on the market by the Stratton Furnace Co., Chicago, Ill.

New Paint for Sealing Joints Against Oil Leaks

DESIGNED FOR effectively sealing joints against oil leaks, a paint has been developed by the General Electric Co. and is sold by the Merchandise Department at Bridgeport, Conn. The product, known as G-E No. 880 Red Protective Paint, is also designed to prevent water and gas leaks as well as for many purposes which require red lead or white lead and is less expensive than either.

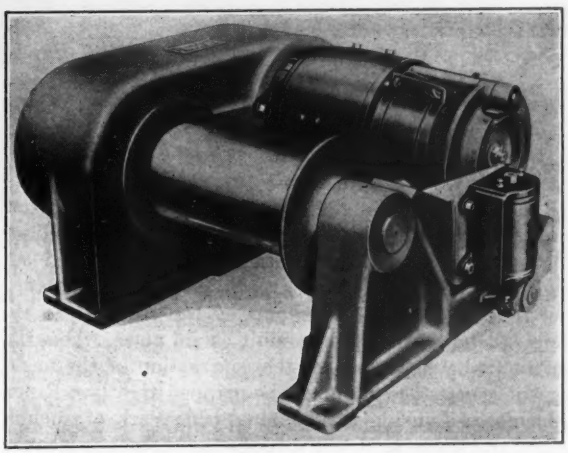
This paint, which is dark red in color, requires no priming and can be applied by brushing or dipping. Denatured alcohol is used as a thinner. It dries rapidly and produces a hard, smooth, glossy film which is easily cleaned and which prevents excessive collection of dirt and conducting material, thereby decreasing surface leakage and subsequent carbonization of the surface when used with electrical apparatus.

One of the first fields in which the paint has been applied is in the manufacture of fuel oil burners, in which one company is now using the material to seal all joints.

New Lo-Hed Electric Hoist

ANNOUNCEMENT is made of a new Lo-Hed electric hoist that can be mounted in a fixed position, either overhead or on the ground, or can be placed on skids and used as a portable hoist. Uses for the hoist include applications for contractors' work, derricks, as a car puller, mine hoist, elevator work, ash handling, coal tipples, loading booms, pulling loads up inclines, furnace door lifting, handling spouts in steel mills, and, in general, all sorts of lifting and hauling that can be done with a hoist in a fixed position.

The standard machine, made by American Engineering Co., Philadelphia, Pa., consists of a smooth drum, driven by a motor through a train of spur gears, all mounted on a common bedplate. It is furnished in sizes for handling loads from 500 to 4500 lb. Motor and gears are completely enclosed. Gears are of drop forged steel, heat treated and run in an oil bath. Hyatt "high duty" roller bearings are mounted on the ends of all gear shafts. The cover of the gear case is easily removable. The drum has large flanges to prevent the rope jumping the ends and give maximum stowage capacity. One bearing of the drum shaft is lubricated by splash from the gears and the other by an Alemite fitting. The motor is a fully enclosed, ball bearing motor, especially designed for hoist service and for either d.c. or a.c. and the controller is of the single speed, reversing drum type.



MOTOR DRIVES DRUM THROUGH TRAIN OF SPUR GEARS

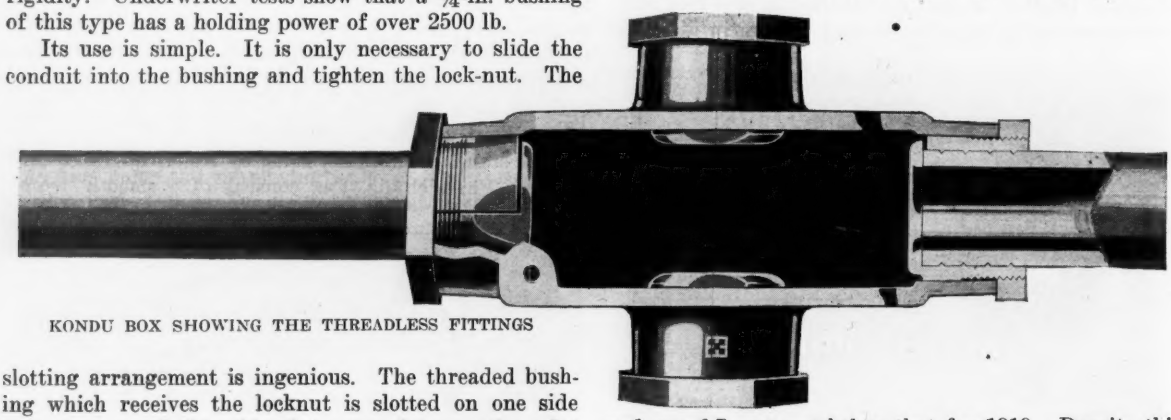
When desired, various modifications in the hoist can be made such as supplying grooved drums, air motors or steam motors, push button and remote control, holding and lowering brakes and extension shafts with additional heads.

Threadless Conduit Fitting Saves Time in Installation

THOSE ENGINEERS who are called upon to do considerable wiring and conduit fitting should be interested in the threadless conduit fitting illustrated on this page, since this device is certain to prove not only a convenience but a time saver in conduit work of all kinds. By the use of this fitting which is made by the Erie Malleable Iron Co. of Erie, Pa., the work and cost of threading the conduit and screwing it into fittings is entirely eliminated.

It consists of the usual type of conduit box fitted with a patented bushing with a special slotting arrangement which grips the conduit with great strength and rigidity. Underwriter tests show that a ¾-in. bushing of this type has a holding power of over 2500 lb.

Its use is simple. It is only necessary to slide the conduit into the bushing and tighten the lock-nut. The



KONDU BOX SHOWING THE THREADLESS FITTINGS

slotting arrangement is ingenious. The threaded bushing which receives the locknut is slotted on one side and at one end this side slot opens into another slot running circumferentially around one-half the bushing. The bushing is tapered. As the locknut is screwed on, due to the taper, the diameter of the bushing decreases, the contraction being taken up by the slot. It is obvious, then, that if the conduit is in place when the locknut is being tightened, the contraction of the bushing will cause the conduit to be gripped tightly. Rings are embossed inside the bushing which are of such a height and shape as to cut through the enamel or lacquer that may be on the conduit, insuring a perfect running ground without the necessity of scraping off this covering. The bushing has four flat sides which keep the bushing from turning inside the box. Tests embracing many fittings installed properly under average conditions show the average resistance of Kondu threadless fittings in a run of conduit to be approximately 0.0005 ohms.

Department of Commerce Analyzes Census of Manufacturers

THE DEPARTMENT OF COMMERCE announces that, according to a summarization of the data collected at the biennial census of manufactures taken in 1926, the value of products (at factory prices) of manufacturing establishments in the United States in 1925 aggregated $62,705,714,000, as against $60,258,470,000 in 1923, $43,427,224,000 in 1921, and $61,737,125,000 in 1919. The 1925 total represents increases of 4.1 per cent over 1923 and 1.6 per cent over 1919. The rate of increase from 1921 to 1925, 44.4 per cent, is, of course, abnormal, and is of interest not as a measure of growth but as indicating the extent of the industrial depression of 1921 and the completeness of the subsequent recovery.

The rate of increase in the actual quantity of production in 1925 as compared with 1919 would be considerably higher than the rate based on values, for the reason that the wholesale prices of manufactured commodities were, on the average, materially lower in 1925 than in 1919. These figures relate to manufacturing establishments whose output during the year was valued at $5000 or more.

The outstanding features of the report are the increase in production, the decrease in the employment of wage earners, and the increase in horsepower, as compard with both 1923 and 1919. The average number of wage earners employed in 1925 was smaller by 4.4 per cent than the corresponding average for 1923, and was 6.7 per cent below that for 1919. Despite this decrease in wage-earner employment, production increased, as pointed out above, and this increase—as might be expected in view of the decrease in wage-earner employment—was accompanied by a considerable increase in horsepower over 1923 and a pronounced increase over 1919, the rates for the two periods being 8.1 per cent and 22 per cent, respectively.

Because the products of many manufacturing establishments are used as materials by other establishments, the aggregate value of products as given above is considerably in excess of the total value of finished manufactured products in the form in which they reach the ultimate consumer. A much better measure of the actual value created by manufacturing processes is the "value added by manufacture"; namely, the difference between the cost of materials (including fuel, mill supplies, containers, etc.) and the factory value of the finished products. This aggregated $26,774,566,000 in 1925, an increase of 3.9 per cent as compared with $25,777,615,000 in 1923 and of 8.2 per cent over $24,748,249,000 in 1919.

W. S. Hovey Is New Head of Fairbanks-Morse

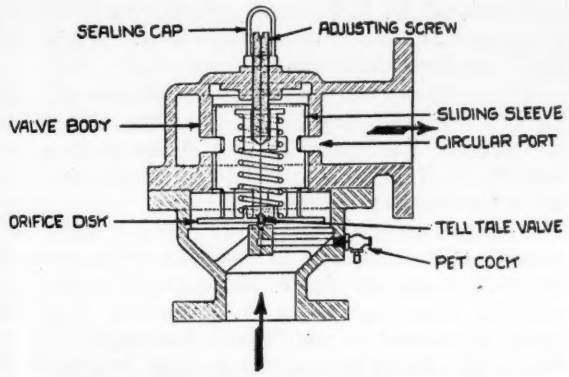
AT AN ANNUAL MEETING of the Directors of Fairbanks, Morse & Co. on March 29, W. S. Hovey was elected president, the former president, C. H. Morse, becoming chairman of the board. This is the first time this position has been held by a man not of the original Morse family.

Born in 1875, a graduate of Cornell, Mr. Hovey joined the Sheffield Car Co., an affiliation of Fairbanks-Morse, in 1902, as assistant superintendent. Later he

became Superintendent, which position he held until 1913, when he was transferred to the Beloit Works of Fairbanks-Morse as manager of the engine division. A few months later he was general manager of that plant. In 1919, he was elected vice president in charge of all the manufacturing activities of Fairbanks-Morse and in 1924 was made general manager of the entire business. He will remain general manager.

Constant Flow Rate Controller

FOR CERTAIN purposes, a constant rate of flow of water, steam, air or other fluid is required, as for example, in the operation of filters, where a certain maximum rate of flow should not be exceeded when filtering, while during the back-washing of the filter a definite constant flow rate is also desirable. A filter operated at too high a rate is inefficient, while in back-washing too small a flow may not wash the sand bed properly and an excessive rate of flow may carry sand out of the filter. For determining the proper rate of flow, filters are sometimes fitted with differential gages connected around an orifice in the pipe line and flow is controlled by the manipulation of valves. This, however, necessitates attention during the whole period of



CROSS SECTION OF FLOW RATE CONTROLLER

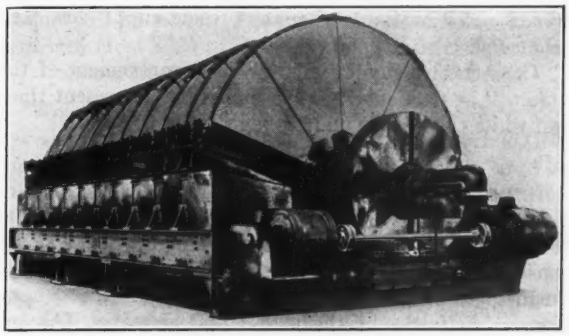
operation, especially if there is any possibility of a change of pressure in the supply line.

Recently the Cochrane Corp., Philadelphia, Pa., brought out a line of automatic flow rate controllers for pipe lines of 1¼ to 14 in. size. As may be seen from the accompanying drawing, the controller contains only one moving part and has no close fits. The difference in pressure set up by flow past a disc in the entrance chamber exerts force upon a valve member in opposition to a spring. When the rate of flow is greater than the rate for which the spring tension has been adjusted, the valve will be shifted towards the closed position and vice versa, coming to rest in a position such that the area through the discharge ports is just sufficient, with the pressure then existing in the supply line, to discharge the predetermined quantity of fluid. In other words, as the spring tension is substantially constant for the small range of valve travel involved, the drop in pressure from one side to the other of the disk must be constant and, as the flow area around the disk is also constant, the rate of flow must be constant. To supply a visible indication that fluid is being passed at the desired rate, a small valve is opened as soon as the disc and valve are moved in opposition to the tension of the spring. This small tell-tale valve is connected to a pet cock which can be opened by the operator. If nothing discharges from the pet cock, it is less than the desired rate and it then will be in order to seek the cause of the deficiency in lack of pressure, stoppage of supply lines or pumps, depletion of supply and the like.

This flow rate controller is designed to have many applications in addition to its use with filters.

Driving Unsupported Shafts Through Flexible Couplings

ALTHOUGH it is often stated that an unsupported shaft cannot be successfully driven through flexible couplings, the American Filter Co., manufacturer of United Continuous Automatic Filters, has successfully



MOTOR AND SPEED REDUCER THROUGH FLEXIBLE COUPLINGS

used Ajax flexible couplings for this work for a long time. The illustration shows an unsupported shaft on the drive end of a United Filter, used for dehydrating cement slurry. The motor, mounted on the right side of the filter, drives a shaft 4 ft. long through an Ajax to an Ajax on the left-hand side, which connects with a D. O. James speed reducer.

Successful driving of this unsupported shaft is due, it is stated, to the precision made parts of the coupling. Rubber bumpers, ground to size, are designed to effect complete insulation and absorb shocks; the bumpers are firmly cemented around bronze bushings and into the holes in the flanges, and are thus protected from dirt, oil and water. Hardened, high carbon steel pins or drive-studs are the connecting medium. They are ground to limits of 0.001 to assure absolute alinement, to eliminate friction, and to prevent binding and vibrating action. Oilless bronze bushings, impregnated with graphite for self-lubrication, and fitted into the bumpers, furnish a bearing for the steel pins. These couplings, produced by Ajax Flexible Coupling Co., Westfield, N. Y., are made on jigs and master dies to assure accuracy and interchangeability of parts.

THE SAN JOAQUIN LIGHT & POWER CO., Fresno, Calif., is planning an expansion and improvement program during 1927 to cost about $13,000,000. This will include extensions in hydro-electric generating facilities, with construction of a new 110,000-v. transmission line and a new power substation.

Refrigerating Code to Be Revised

ACCORDING TO an announcement by the American Engineering Standards Committee, the Refrigeration Safety Code is to be revised. For this work, the personnel of the sectional committee which now has 35 members representing 23 organizations is being reorganized. The Refrigeration Safety Code deals with the subject of Refrigerating Equipment under three main divisions made as to capacity. Refrigerating equipment falling in a certain class as to capacity is further classified as to the working medium or refrigerant employed.

A limited number of copies of the proposed code are still available and may be had by addressing the American Engineering Standards Committee, 29 West 39th Street, New York City, or the American Society of Refrigerating Engineers, 35 Warren Street, New York City. Due to probably slight revisions and additions to the code, there will be no further copies of the present draft available after the present supply has been exhausted.

Constructive suggestions for the improvement of the code will be particularly appreciated at the present time, and while the code is undergoing revision.

News Notes

AT THE MEETING of the New England Council at the Hotel Statler, Boston, Mass., on Friday, March 25, considerable discussion was given to the stimulation of business associations of various kinds and the general business activities of the New England states. Among the many prominent speakers were Chas. L. Edgar, president of the Edison Electric Illuminating Co. of Boston, Martin Insull, and President Hannauer, of the Boston & Maine R. R.

STONE & WEBSTER, INC., Boston, Mass., on March 22 took over actual executive control of the Lowell Gas Light Co. and by so doing extended its control to both local lighting corporations. It has managed the Lowell Electric Light Corp. for a number of years.

At the annual meeting of the gas company shareholders on the same day Austin K. Chadwick was elected president to succeed Geo. S. Motley, who retired after many years' affiliation with the company. Henry B. Sawyer, of Stone & Webster, Inc., was chosen treasurer.

THE BROWN INSTRUMENT CO. of Philadelphia, Pa., has opened a Midwestern Repair and Service Station at 217 E. Illinois St., Chicago, Ill., telephone Superior 6615. This service station will have factory trained mechanics in charge and will also carry charts, thermocouples, protecting tubes, extension leads and stock instruments, so that the same service can be given as from the main factory.

HOWE CHAIN CO., Muskegon, Mich., a subsidiary of Link-Belt Co., Chicago, has recently applied the new trade name "Jak-Tung" to the small three-wheeled truck which it manufactures either for hauling or for storage. This truck consists of a platform equipped with two malleable iron wheels at the rear and a malleable iron drawbar in the front. The jack tongue, whence the truck takes its name, together with the wheel, hooks into the drawbar leg and, by a downward thrust of the handles, the load is raised for hauling. The truck is built in 17 different sizes and three models with various combinations of platform construction and is designed to handle equipment up to 3 t. in weight.

MAGNOLIA METAL CO., New York, announces that the head office and factory of its Canadian branch has been moved to 338-A St. James St., Montreal, P. Q.

TURNER CONSTRUCTION CO. announces the removal on April 2, 1927, of its main office to the Graybar Bldg., 420 Lexington Ave., New York City.

MCCLAVE-BROOKS CO., Scranton, Pa., announces that on and after the middle of April its Chicago district office will be at 1620 Conway Bldg., Chicago, Ill., instead of 1510 Conway Bldg. Alfred Lotz is district manager.

NATIONAL ELECTRICAL MANUFACTURERS' ASSN. has moved its headquarters office to the Graybar Bldg., 420 Lexington Ave., New York City, according to an announcement by Alfred E. Waller, managing director.

THE CITY OF MT. PLEASANT, IA., is adding to its present electric light plant and water works a new 800-hp. Murray uniflow engine. C. W. McMillan is the superintendent of this plant.

HOMESTEAD VALVE MFG. CO., INC., Homestead, Pa., has appointed W. R. Ladewig, 238 So. San Pedro St., Los Angeles, Calif., as its exclusive factory representative in southern California.

DAYTON-DOWD CO., Quincy, Ill., announces the opening of a new sales office for the Carolinas in charge of the Murphey Equipment Co., 212 Wilder Bldg., Charlotte, N. C. This company is also the district representative for Georgia and Florida.

THE EDWARD VALVE & MFG. CO., East Chicago, Ind., is now being represented in the Minneapolis territory by H. J. Meier, 459 N. W. National Life Bldg., Minneapolis, Minn., succeeding W. P. Nevins. It is also being represented in the Detroit territory by E. W. Nicklin Co., 12-231 General Motors Bldg., Detroit, Mich., succeeding Richards-Nicklin Co.

R. H. BEAUMONT CO., Philadelphia, Pa., announces that it has taken over the business of the American Mfg. & Engrg. Co., Kalamazoo, Mich., and the products formerly manufactured by that company, including the American Slackline Cableway Excavator, will now be manufactured by the R. H. Beaumont Co. S. O. Nafziger, president of the American Mfg. & Engrg. Co., will now be associated with the R. H. Beaumont Co.

FAIRBANKS, MORSE & CO., Chicago, Ill., has taken over the scale business of The Fairbanks Co. of New York, it was officially announced recently.

In 1916 Fairbanks-Morse purchased E. & T. Fairbanks and Company, with its scale factories at St. Johnsbury, Vt., and East Moline, Ill. The Fairbanks Co. of New York, however, held the distributing rights for Fairbanks Scales in the Eastern and Southern portions of the United States and abroad. The present transaction, therefore, gives Fairbanks-Morse complete control of the manufacturing and distribution of Fairbanks Scales. A scale manufacturing plant at Birmingham, England, as well as the London sales agency and all other sales agencies throughout the world, are included in the deal.

As a result of invention of the platform scale in 1830 by Thaddeus Fairbanks, E. & T. Fairbanks and Company was organized. In 1858 they sent Mr. Greenleaf and C. H. Morse to Chicago to establish an agency under the name of Fairbanks & Greenleaf, for the distribution of Fairbanks Scales in the Western territory. In 1871 the name of the firm was changed to Fairbanks, Morse & Co., when C. H. Morse took charge of the business. As the company grew, it acquired manufacturing plants at Beloit, Wis., Indianapolis, Ind., and Three Rivers, Mich. The Fairbanks Co. of New York will continue to manufacture valves and sundry other products at Binghampton, N. Y., and wheelbarrows and industrial trucks at Rome, Ga.

American Engineering Co., Philadelphia, Pa., announces that J. S. Bennett, of its engineering department, has been selected by the Towne Scientific School, University of Pennsylvania, to deliver a series of lectures on stoker firing as part of the new graduate course in fuel engineering to be inaugurated at the university next year.

George L. Ohrstrom & Co., New York, has acquired a controlling interest in the Peoples Light & Power Corp. heretofore operated by the W. B. Foshay Co., Minneapolis, Minn. The company is capitalized at $25,000,000 and operates 25 electric light and power utilities in 15 different states. The Foshay Company, it is stated, will soon perfect plans for the formation of another utility group to take over holdings in Arizona, Kansas, Idaho and Utah.

The Northern Ohio Power & Light Co., Akron, O., has approved an expansion program for 1927 involving about $1,650,000. The work will include additions to the power substation at South Akron, increase in transformer capacity of the new Riverside Station, new switching and distribution stations and extension in the underground conduit systems and overhead distributing systems in Akron.

Cities Service Co., New York, an interest of Henry L. Doherty & Co., plans the construction of a new transmission line from Sandusky, Ohio to a point near Toledo to connect the properties of the Ohio Public Service Co. with the system of the Toledo Edison Co. The new line will be about 50 mi. long, is of the steel tower double circuit type and will operate at 132,000 v.

Turners Falls Power & Electric Co., Turners Falls, Mass., has organized a voluntary association known as the Western Massachusetts Companies, as a holding company. The company plans to effect economies in operation by acquiring control of stock of five distributing companies which now handle the product of the Turners Falls company.

The Campbell Soup Co., Camden, N. J., plans the installation of a boiler plant at its canning factory at West 35th and Rockwell Sts., Chicago. Battey & Kipp, of Chicago, are architects and engineers.

Day & Zimmerman, Inc., Philadelphia, engineers, operating electric light and power utilities in different parts of the country, has purchased a controlling interest in the National Public Service Corp., heretofore held by A. E. Fitkin & Co., New York, and will operate in the future. The holdings include properties in New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Georgia, North Carolina and Florida, comprising electric light and power utilities, gas companies, water and ice interests. The electrical properties have an installed generating capacity of 237,116 hp., with 1980 mi. of high-tension transmission lines. The entire group of properties serves a total population in excess of 2,000,000 people. The principal utilities are the Jersey Central Power & Light Co., Virginia Public Service Co., Municipal Service Co., and the Tidewater Power Co. The new owner plans to improve and expand the different holdings, including power plant and transmission line construction. John E. Zimmerman will become president of the organization.

To meet the increasing demands for electric light and power in Trenton, N. J., equipment at the Olden Ave. substation of the Public Service Electric & Gas Co. will be increased this year. The substation will be changed over from two-phase to three-phase operation and a general re-arrangement of the apparatus in the station will be made. The transformer capacity will be increased from 8000 to 12,000 kv.a. Public Service Production Co. will do the work.

Work has been started on the construction of the new steam plant of the Rochester Gas and Electric Corporation at the west end of the city. The plant is to be built on the same general plan as that now in operation in Lawn St. on the east side, which supplies steam heat to a large part of the business district. The new building will be approximately 108 ft. long by 70 ft. wide. Two 1000-hp. steam boilers will be installed and provision will be made for additional equipment as needed. It is estimated the plant will cost in the neighborhood of $1,000,000. Industrial plants in the Lincoln Park district at the western end of the city will be served.

At Sherman, Mass., on the Deerfield River near the Vermont line, the New England Power Co. has started operating its new power station and is generating 10,000 hp., which at 110,000 v. is sent over the high voltage lines to Millbury for distribution in Massachusetts and Rhode Island. Water power is supplied by an artificial lake covering 250 acres and extending back to the tailrace of the Davis Bridge hydro project. The Sherman station is wholly automatic. The new development is an intermediary power project and prevents what otherwise would be waste water. The dam for the project is 700 ft. long, 95 ft. high and 500 ft. wide at its maximum point.

At its meeting on March 15 the Federal Power Commission, Washington, D. C., voted to suspend for the present the consideration of all applications for power projects on the Clinch River, on account of the possible relation of these projects, especially the proposed Cove Creek storage reservoir, to the utilization or disposition of Muscle Shoals. The commission authorized a preliminary permit to the Oroville-Wyandotte Irrigation District for a power project on the South Fork of the Feather River and its tributaries, including the development of a 60,000-hp. hydro-electric plant. The commission also authorized an extension for one year of the preliminary permit originally issued to the Roanoke River Power Co. for its 50,000-hp. project near Clarkesville, Va.

BUSINESS AND CIVIC ORGANIZATIONS of Maine are making a drive this year to secure public support for amending the state law, now prohibiting the export of power across the boundaries of the state. This is the foremost civic question in the state and the movement for the change in the law has been sponsored by scores of Chambers of Commerce, Boards of Trade, clubs and associations.

Of all of the states of the Union, Maine alone forbids the export of power from within its borders. Walter S. Wyman, president of the Central Maine Power Co., declares this law should be modified or repealed, to permit surplus power to be exported. He points out that it would be an advantage to manufacturers, power companies and to all classes of citizens; that it would make possible lower power rates; that it would lead to the investment of millions in property in the state and that it is reasonable to believe that it would lead to a million dollars in additional revenue from taxation alone within ten years.

Catalog Notes

MAGNOLIA METAL CO., New York City, has just published for free distribution a new and revised edition of the Magnolia Bearing Metal Handbook. This 96-page handbook contains data, suggestions and instructions on the selection and preparation of bearing metals for various services, illustrated with sketches showing methods of arranging shells, proper proportions and clearances of bearings and various arrangements of oil grooves with which good results have been obtained in service.

THE LINCOLN ELECTRIC CO., Cleveland, Ohio, has just issued the 1927 edition of the Instruction Manual. This publication is revised annually to cover the latest practice in manual electric arc welding and discusses, among other things, high speed steel welding, high pressure pipe welding, boiler repairs, welding of cast iron and manganese steel and equipment using welded steel in place of castings. The price of the Instruction Manual is $1.00.

BOSTON GEAR WORKS SALES CO., Norfolk Downs, Quincy, Mass., in a 192-page booklet describes all types of standardized Boston gears and gives dimensions and price lists of them.

AUTOMATIC PRIMER CO., Chicago, Ill., in Bulletin No. 327 recently issued, describes and illustrates the Apco primer designed to prime automatically any type of centrifugal pump.

O. ZERNICKOW CO., New York City, in a recent 6-page bulletin describes and illustrates O-Z hand and stationary tachometers. These are made in many types for measuring of speeds of all types of rotating machinery and are designed as precision instruments, the latest type having a 6-in. dial. One type is made to draw graphic speed curves on a stripchart.

FROM GRADON MFG. CO., Land Title Bldg., Philadelphia we have received catalog binder with Bulletin No. 11 on wrought construction expansion joints of sliding sleeve type, Bulletin No. 21 on steam separators of plain and receiver type, Bulletin No. 31 on storage water heaters of U type. The bulletins give full information as to construction, dimensions and prices of the equipment.

THE INTERNATIONAL NICKEL CO., New York, has recently issued an eight-page illustrated bulletin entitled "100 Years of Steel Improvement." This is a sequel to the booklet "Paving the Way for Alloy Steel." It contains an analysis of the many uses of nickel alloy steels in industry, together with reprints of some advertisements.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April 1, 1927.

State of Illinois, } ss.
County of Cook. }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse side of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 22nd day of March, 1927.

Alice Tippett.

(My commission expires October 7, 1928.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

That Power and Light Shall Not Fail

Sudden paralysis recently gripped the nervous system supplying power to the heart of a great city when electricity in its multiple forms was cut off by a fire.

Twenty-five and thirty stories up people were left stranded through failure of elevator service. Lights were out. Business practically ceased to function in the nearby area during the busy part of a business day.

Forty-five years ago electricity was first generated commercially in this city. First installations were those put in stores as a novelty to attract customers more than as a means of lighting.

Men patrolled these installations, visiting each one at about three-hour intervals.

How electricity, the medium of power and light, has grown in this time every power plant man knows. Today its wires are woven overland and underground, throughout homes, office buildings, factories, shops—wherever people live, work or play.

Rarely, indeed, does an accident occur in any part of a system of power generation and transmission that becomes known to the public through interruption of service. And when even a brief interruption occurs, it serves to make us realize how indispensable to health, wealth and the pursuit of happiness is the might of mechanical power.

On June 4th, next, the Exhibition in connection with the 50th Convention of the National Electric Light Association will open at Atlantic City. The next issue of this publication, that of June 1, will be read by the delegates to the convention and copies will be distributed from Power Plant Engineering's booth, No. 109, in the Exhibition.

Year in and year out, editors, leading engineers throughout the world and manufacturers of machinery and equipment have been giving in these pages, ideas, methods and information from their work that power and light shall not fail.

Today the industry which this publication serves has attained a position where brief interruptions of service are the least vital of failures.

Where power abounds, civilization advances. Today, countrysides as well as great urban districts prosper or stand still, build greater or wither, in proportion as power and light are made available and economical.

No magic wand could conjure up the realities that power on wires is creating! As new power plants are built, higher efficiencies attained and the antennae of wires extend out and are linked up with those of other plants, the lives of the people expand into a higher order of being.

The interchange of ideas and the exhibits of manufacturers both at Atlantic City and in the pages of the June 1 Convention Number of Power Plant Engineering, should result in a still further advancement of the power plant field and of the nation as a whole.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allen & Billmyre Co., Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Binks Spray Equipment Co., Chicago, Ill.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Yeomans Bros. Co., Chicago.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Forge Co., Buffalo.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS
Dampney Co, of America, Boston.

ARCHES, BOILER COMBUSTION.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Girtanner Eng. Corp., N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hoff Co., The M. A., Indianapolis, Ind.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Conveyors Corp. of America, Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Eng. Corp., N. Y.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Eng. Corp., N. Y.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.

BAROMETERS.
Taylor Instrument Co's, Rochester, N. Y.

BEARING METAL.
Magnolia Metal Co., New York.

BEARINGS, ROLLER.
Timken Roller Bearing Co., The, Canton, Ohio.

BELT CONVEYORS.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING.
Crandall Pkg. Co., Palmyra, N. Y.
Goodyear Tire & Rubber Co., Inc., Akron, O.
Quaker City Rubber Co., Philadelphia, Pa.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN AND FURNACE.
Air Preheater Corp., The, New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
McClave-Brooks Co., Scranton.
Sturtevant Co., B. F., Boston.

BLOWERS, PORTABLE.
Allen & Billmyre Co., Inc., New York.
Clements Mfg. Co., Chicago, Ill.
Sturtevant Co., B. F., Boston.

BLOWERS, PRESSURE.
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL.
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM.
Schutte & Koerting Co., Philadelphia, Pa.

BLOWERS, TUBE.
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach. Fdry. & Supply Co., Marion, Ind.
Sherwood Mfg. Co., Buffalo.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BLOWERS, TURBINE.
Allen & Billmyre Co., Inc., New York.
Elliott Co., Jeannette, Pa.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Boiler Engrg. Co., Newark, N. J.
Engineer Co., The, New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COATINGS
Dampney Co. of America, Boston.

BOILER COMPOUNDS.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chem. Co., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS.
Boiler Engrg. Co., Newark, N. J.

BOILER FEEDWATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., New York.
Permutit Co., The, New York.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Insulating Products Corp., New York, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 162

BOILER SETTINGS.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER TUBE CLEANERS.
General Specialty Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.
Sherwood Mfg. Co., Buffalo.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Insulating Products Corp., New York, N. Y.

BOILERS.
Babcock & Wilcox Co., New York.
Badenhausen Corp., Cornwells Heights, Pa.
Brownell Co., The, Dayton, O.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Wks., Erie.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Works, Erie, Pa.
Vogt Mach. Co., Henry, Louisville, Ky.
Wickes Boiler Co., The, Saginaw, Mich.

BOOKS AND SCHOOLS.
Audel & Co., Theo., New York.

BREECHINGS.
Connery & Co., Inc., Philadelphia.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brady Conveyors Corp., Chicago.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAM SHELL.
Orton Crane & Shovel Co., Chicago.

BUCKETS, COAL HANDLING.
Orton Crane & Shovel Co., Chicago.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Erie City Iron Works, Erie, Pa.
Fuller Lehigh Co., Fullerton, Pa.
Girtanner Eng. Corp., N. Y.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, FURNACE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Insulating Products Corp., New York, N. Y.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT GUNS.
Cement - Gun Co., Inc., The, Allentown, Pa.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CEMENT, INSULATING
Insulating Products Corp., New York, N. Y.